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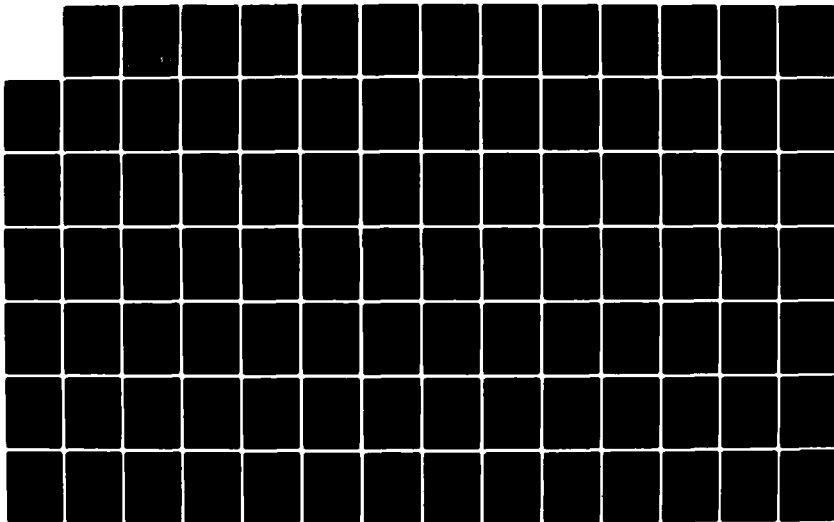
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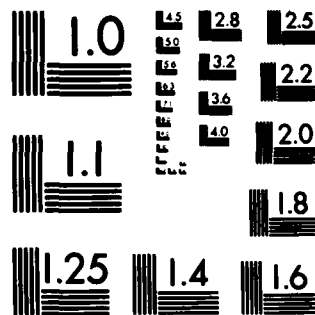
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**THE WEAPONS SUPPORT SYSTEM
MULTISENSOR SIMULATION SOFTWARE
PROGRAM DOCUMENTATION**

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PREFACE

Documentation for the Weapons Support System (WSS), developed for the Defense Mapping Agency by The Analytic Sciences Corporation, consists of a User's Guide (TR-1946-1) that gives an overview of the WSS hardware and software, as well as detailed operating instructions for the major application areas listed below; and four volumes of detailed program documentation:

- Gravity Data Evaluation Software (TR-1946-2)
- Data Smoothing and Spectrum Analysis Programs (TR-1946-3)
- MULTISENSOR Simulation Software (TR-1946-4)
- GEOFAST Software Documentation (TR-1946-5).

This volume, MULTISENSOR Simulation Software Program Documentation, documents the programs developed to carry out the MULTISENSOR simulation, at a level suitable for use by programmers who will be adapting or modifying these programs. It is intended for use in conjunction with the Weapons Support System User's Guide and relevant operating system (VAX/VMS) documentation.

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PROGRAM OVERVIEW

1.1 INTRODUCTION

The multisensor simulation software is designed to analyze the effects of multisensor surveys of the gravity field on gravimetric estimation errors and weapon system performance. The analysis methodology on which this software is based was developed by TASC for the Air Force Geophysics Laboratory and the Defense Mapping Agency and is reported in Ref. 1. The program is ideally suited for the design of multisensor surveys to achieve a desired level of accuracy in gravity recovery or weapon system performance.

1.2 GENERAL SOFTWARE OVERVIEW

The multisensor simulation software package consists of three programs. They are described below.

- MULTISENS is the main multisensor simulation program; it will analyze a trajectory to compute the transfer function relating gravimetric errors to impact errors, simulate the user-specified multisensor surveys to compute the postsurvey residual gravimetric error statistics, and use the results of these two calculations to compute the statistics of impact errors induced by the residual gravity field. It can also analyze the sensitivity of the computed error statistics to any one of a set of survey model parameters. It can be run interactively, or submitted as a batch job.
- MULTIJOB is an interactive program written to guide the user in setting up a control

stream for input to MULTISENS. Because of the abundance of options available in MULTISENS, some of which are mutually exclusive, use of this program can simplify the process of selecting and specifying the run to be made.

- MULTILOT is an interactive program which enables the user to view and modify MULTISENS plots. The MULTISENS program offers the user the option of generating printed plots during the run, or of generating and saving a plotting data file which may subsequently be processed interactively using MULTILOT.

Each of these programs is documented separately in the sections which follow.

1.3 DOCUMENT OVERVIEW

Section 2 of this document is a user's guide, providing the information necessary to run the programs and interpret the output. It contains a separate subsection for each of the three programs in the package; each such section includes a description of the program options available and how they are invoked, the variable model parameters and their default values, the format of the input and output files, and a summary of the calculations performed.

Sections 3 through 5 describe the internals of the three programs. These sections are provided for use by programmers in maintaining and modifying the programs. Each of these sections contains subsections which describe:

- The program's organization
- Its main routine

- Its common blocks, with a listing of the variables in each block
- A list of all the subroutines in the program
- A detailed description of the upper-level subroutines.

2. USER'S GUIDE TO THE MULTISENSOR SURVEY SIMULATION SOFTWARE

2.1 APPLICATIONS OF THE MULTISENSOR SURVEY SIMULATION SOFTWARE

The multisensor survey simulation software consists of three different programs: MULTISENS, MULTIJOB, and MULTIPLOT. The purpose of these three programs is discussed below.

MULTISENS allows the user to analyze the effects of multisensor surveys of the gravity field on weapon system and gravity estimation errors. The analysis on which the program is based was developed by TASC for the Air Force Geophysics Laboratory and the Defense Mapping Agency and is reported in Ref. 1. The program is ideally suited for the design of multisensor surveys to achieve a desired level of weapon system or gravity recovery accuracy. The program allows the user to consider surveys consisting of any combination of

- Satellite-to-satellite (SST) range-rate data (high-low configuration)
- Gravimetric data (land-based or ship survey)
- Satellite radar altimetry data (up to two missions)
- Airborne gradiometry data.

All parameters which describe the survey geometry and sensor error models can be modified by the user. In addition, the user can define any trajectory profile. The statistics of the unsurveyed (a priori) gravity field can be selected from a

collection of built-in models or can be defined through numerical data tables or through a user-supplied subroutine.

Outputs are printed and/or plotted. They consist of the statistics of postsurvey gravity residuals and the impact miss inflight gravity contribution that would result from compensation using the survey gravity estimates along the trajectory. The statistics of postsurvey gravity residuals are given in the form of root-mean-square (RMS) values, correlation coefficients, spectral densities, and covariances of point values and spatial averages of gravimetric quantities. The output statistics of miss are RMS downrange and crossrange errors as well as their associated CEP.

The programs MULTIJOB and MULTILOT serve as tools for the creation of inputs or the analysis of outputs from MULTISENS. MULTIJOB permits the interactive creation of control input files for running MULTISENS, while MULTILOT allows the user to examine the output plots produced by MULTISENS, change scales, or obtain hard copies of these plots, all interactively. Recommendations on running the programs MULTISENS, MULTIJOB, and MULTILOT are given in sections 2.2, 2.3, and 2.4 respectively.

2.2 RUNNING THE MULTISENS PROGRAM

The MULTISENS program contains three major calculations or phases; a given run may perform all three phases, or any subset of the three. These phases are:

- **TRANSFER.** This phase of the program reads an input trajectory file and computes the inflight transfer function table, which maps components of the geoid

undulation error spectral density into impact errors for that trajectory. This table is written to a file (TRANSFILE).

- **GRAVITY.** This phase of the program computes multisensor postsurvey residual gravity error spectral densities and covariances. The program prints and plots the statistics of the residual errors for a set of user-selected gravimetric quantities, and may also write a table of residual geoid undulation spectral densities to a file (GRAVFILE).
- **IMPACT.** This phase of the program uses the files generated by the other two phases to compute the impact errors associated with the given trajectory arising from the postsurvey residual gravity errors.

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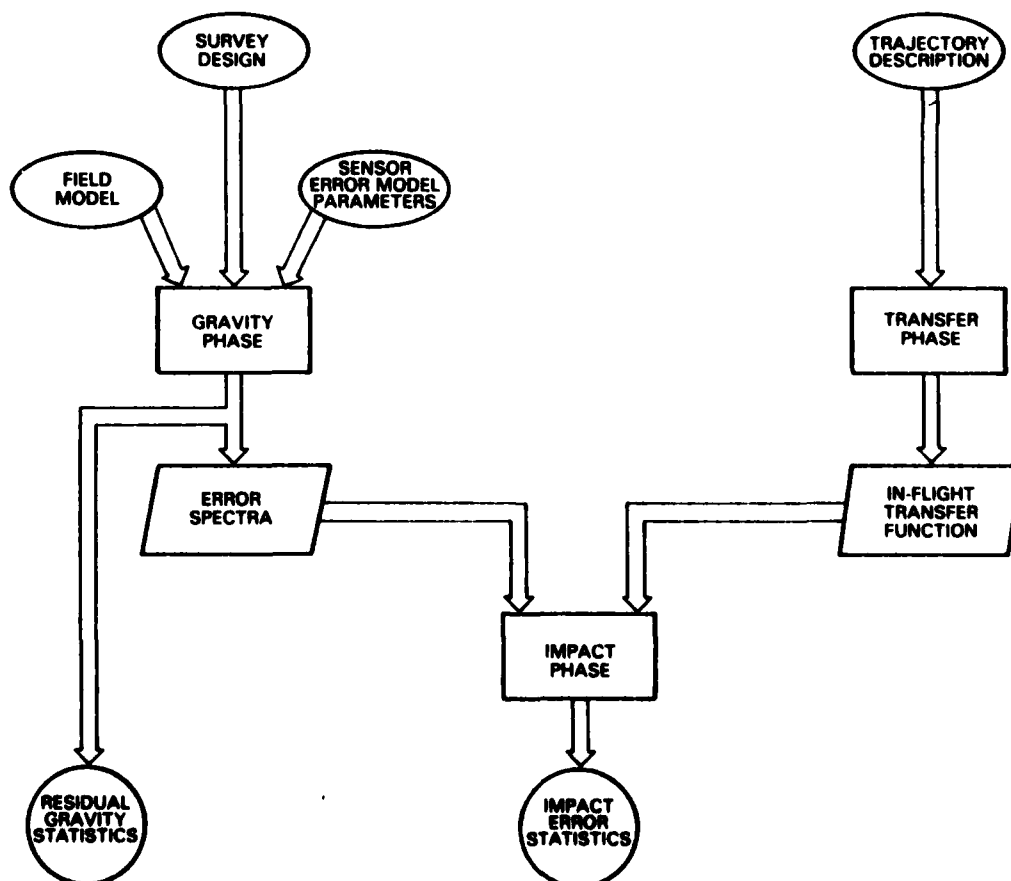


Figure 2.2-1. MULTISENS Functional Macrodiagram

Figure 2.2-1 illustrates the relations among the three phases of the program. The program is designed to enable the user to generate a single transfer function file and then make a series of impact error calculations for that trajectory using various surveys, field models, and/or sensor error model parameter values; alternatively, a single gravity error file may be used in order to compute corresponding impact error statistics for a set of trajectories.

For any MULTISENS run, a single control file is used to specify options for all the phases to be performed. The user may construct this file either by typing the specifications directly into the file using the instructions in this chapter of the User's Guide, or by executing the interactive program MULTIJOB, which prompts the user for run options and generates a control file which may be used as input to MULTISENS. The program can then be run as a batch job using the SUBMIT command by typing

SUBMIT FILENAME

or it can be run at the terminal using the execute procedure @ command by typing

@FILENAME

where FILENAME represents the name assigned by the user to the input control file. See Volume 2A of the VAX/VMS Reference Manuals for detailed information on the SUBMIT and @ commands.

MULTISENS reads its control input in the NAMELIST format, which is documented in Appendix B. In this format, the input is read as a series of specifications in the form:

variable-name1 = value1, variable-name2 = value2;

the list being terminated by a semicolon. A semicolon appearing in the middle of the file will cause the remaining specifications to be ignored; for this reason character values should not include semicolons. Note that the variable names and alphameric values read from this file are expected to contain only upper-case characters and that the order in which they are listed is immaterial. A complete list of the variable names and default values is provided in Appendix A. In general, variables whose values are not specified in the input are assigned default values by the program. Exceptions to this rule are the variable TYPE_OF_RUN which indicates what phases of the program are to be executed, and the names of input files, if any are required.

The variable TYPE_OF_RUN, for which a value must be specified in the input, is a character string three-vector, whose elements may be set to any combination of the strings TRANSFER, GRAVITY, and IMPACT. If more than one phase is to be executed, the list of values must be enclosed in parentheses, as in the examples below.

- TYPE OF RUN = TRANSFER will cause only the TRANSFER phase to be executed. This run will require an input trajectory file.
- TYPE OF RUN = IMPACT will execute only the IMPACT phase. It will require as input both an inflight transfer function file previously generated and saved by the TRANSFER phase, and a residual geoid undulation spectral density file previously generated and saved by the GRAVITY phase.
- TYPE OF RUN = (GRAVITY, IMPACT) will execute both the GRAVITY and IMPACT phases; the IMPACT phase will require as input a previously generated inflight transfer-function file, as

well as the output of the GRAVITY phase. The order in which the values are listed does not affect the order in which the phases are executed; the same run could be made by coding TYPE_OF_RUN = (IMPACT, GRAVITY).

- TYPE_OF_RUN = (TRANSFER, GRAVITY, IMPACT) will perform all three phases, requiring only a trajectory file as input.

Any run which includes the execution of the TRANSFER phase requires the specification of an input trajectory file. If the same run specifies IMPACT, the inflight transfer function table generated during the TRANSFER phase will be used in the evaluation of the statistics of the miss vector.

Similarly, if the vector TYPE_OF_RUN includes both GRAVITY and IMPACT, the gravity residuals computed during the GRAVITY phase will be used as input to the impact phase. The impact error statistics will then correspond to the survey conditions, gravity model, and sensor error model parameters specified for the GRAVITY phase.

The input control file can be thought of as consisting of up to five blocks as shown in Fig. 2.2-2. The first block contains the single statement describing TYPE_OF_RUN. The blocks labeled TRANSFER, GRAVITY, and IMPACT phase controls contain descriptor values which characterize the execution of each of these phases. These are discussed in sections 2.2.1, 2.2.2 and 2.2.3 respectively.

The SENSITIVITY option control input block of Fig. 2.2-2 allows the user to obtain a collection of gravity residual or impact error statistics corresponding to various values of any single input parameter associated with the GRAVITY phase for a fixed trajectory. This option, which is described in detail in section 2.2.4, will cause repeated

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TYPE_OF_RUN SPECIFICATION
TRANSFER PHASE CONTROLS
GRAVITY PHASE CONTROLS
IMPACT PHASE CONTROLS
SENSITIVITY OPTION SPECIFICATIONS

Figure 2.2-2. Input Control File

execution of the GRAVITY phase and of the IMPACT phase if so specified through the SENSITIVITY parameter. Use of this option always requires the inclusion of GRAVITY in the vector TYPE_OF_RUN. If miss statistics are to be evaluated under this option, IMPACT should also be included in TYPE_OF_RUN. If these restrictions are not satisfied by the specification of TYPE_OF_RUN, the setting of SENSITIVITY will cause the program to print warning messages and to modify the values entered for TYPE_OF_RUN in order to construct a self-consistent set of control inputs.

Not all possible settings of the GRAVITY phase control inputs are consistent with the execution of the IMPACT phase in the same run. The only GRAVITY phase outputs compatible with the simultaneous specification of IMPACT in TYPE_OF_RUN are the root-mean-square (RMS) values of the point gravity residuals. This requires that the input GRAVITY parameter MODE be equal to its default value RMS (see section 2.2.2).

2.2.1 Running the TRANSFER Phase

The inflight transfer function describes the relation between high-frequency gravity residuals and impact errors. A complete discussion of the theoretical basis for the definition and construction of the inflight transfer function is given in Ref. 1. For each frequency pair (F1,F2) with F1 and F2 measured in the east and north directions respectively, the inflight transfer function assigns the values of downrange and crossrange miss which are induced on a trajectory by a complex surface potential of the form

$$T(x,y) = \exp (i[(F1)x + (F2)y])$$

with $i^2 = -1$; x and y are measured in the east and north directions in such a way that the origin of the coordinate system coincides with the launch point.

The TRANSFER phase of MULTISENS evaluates the inflight transfer function for selected values of the frequency pair (F1,F2) by solving for each pair the differential equations which describe the errors induced by gravity in an inertial navigator. The frequency pairs (F1,F2) form a grid as shown in Fig. 2.2-3. The range of values of F1 is 0, (F0), 2(F0), ... $2^{(NFM1-1)}(F0)$ and that of F2 is $-2^{(NFM1-1)}(F0)$, ..., 0, ..., $2^{(NFM1-1)}(F0)$ with $F0 = 1/LAMBDA0$ where LAMBDA0 and NFM1 are optional input variables described below. Negative values of F1 are not included in the table since the corresponding values may be derived from the computed entries.

To compute the inflight transfer function, the program needs two input files: a trajectory file describing the path of the vehicle for which the computation is to be made, and the control input which directs the computation.

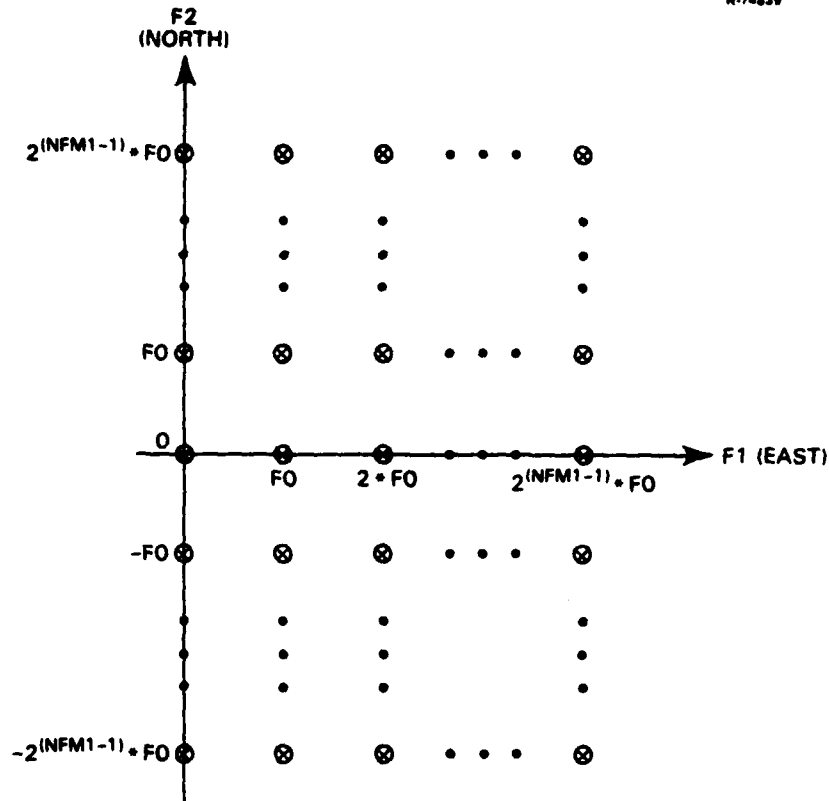


Figure 2.2-3 Frequency Pairs for Transfer Function Table

Trajectory File

The format of the standard input trajectory file is described in section 2.2.5. It should consist of a series of records each containing the time value, position vector, and velocity vector at appropriate intervals in the trajectory.

If the program is required to use a trajectory file in a different format, the user must supply a replacement for the standard MULTISENS subroutine GETTRAJ. Since all access to the trajectory file takes place through this routine, no further program modifications should be necessary. The user's version should return to the program the time, position, and

velocity in the units and coordinate system described in section 2.2.5. For a detailed description of the subroutine and its calling sequence, refer to section 2.2.6.

Control Input

The control input for the inflight transfer function calculation should include:

- A specification for TYPE_OF_RUN that includes the value TRANSFER.
- The filename of the input trajectory file (TRAJFILE).
- The optional filename of the output transfer function (TRANSFILE). If this parameter is omitted, the output will be written to a temporary file, which will be passed to the IMPACT phase (if specified), and deleted at the end of the run. If a filename is specified, the file will be retained after the run is completed.
- Optional specifications for any of the other input parameters (listed below) whose default values are to be overridden.

The following additional parameters are relevant to the TRANSFER calculation.

TDEPLOY This is a time in seconds from launch after which a stepsize of a minimum of ten seconds is sufficient to obtain appropriate results in the propagation of the solution of the differential equations. A reasonable choice for TDEPLOY is the time of deployment for the particular trajectory being analyzed. Unless overridden by the user, its value defaults to 400 sec.

LAMBDA0 Longest non-DC wavelength (in nautical miles) to be used in generation of the transfer-function table. The default is 2400 nm.

NFM1 The number of positive east and north frequency entries to be included in the transfer function table. The default is 10.

CRIT Threshold value for a criterion to determine the stepsize for propagation of the solution. Longer stepsizes are used if the height of the missile is such that the upward continuation attenuation factor for the particular frequency pair being analyzed is less than CRIT. The default value is 0.01.

NWAVE Number of subdivisions of a wavelength to be considered when determining the propagation stepsize. The default value is 12.

DEBUG Logical switch which may be set to generate extra printout from the transfer function calculation. Its default value is .FALSE. (i.e., no debug printout).

MDEBUG Index between zero and NFM1 inclusive. If the DEBUG switch is set, maximum detail printout will be generated for all frequency pairs in which at least one of the frequencies is indexed by MDEBUG. The default value is 0.

Printout

Default printout from the TRANSFER phase is limited to the computed inflight transfer function table. Debug printout contains in addition:

- A printout of the contents of an intermediate scratch file, containing a selection of the trajectory points expressed

in local flat-earth coordinates and corresponding rotation matrices relating earth-fixed coordinates to the inertial coordinate system underlying the computation.

- A collection of state transition matrices from launch to selected times along the trajectory.
- Miss partial matrices from launch to impact.
- Tables of sines and cosines used in the computation.
- Tables of propagation time selection, upward continuation attenuation factors, and state solutions (position and velocity errors) as functions of time for all frequency pairs (F1,F2) in which at least one of the frequencies is indexed by MDEBUG.

Output File

The computed inflight transfer function is written to an output file whose name is specified as the TRANSFILE parameter in the control input. If the TRANSFILE parameter is missing from the control input, a temporary file is created, which is deleted at the end of the run. The format of this file is described in section 2.2.5.

2.2.2 Running the GRAVITY phase

The GRAVITY phase computes the statistics of multi-sensor postsurvey residual gravity errors. The theoretical basis for the evaluation of the postsurvey residuals is given in Ref. 1. The two-dimensional power spectral density of the residuals in the undulation of the geoid, S, is given at each frequency pair (W1,W2) by

$$S = 1 / (A(1) + A(2) + \dots + A(N) + 1/S_0)$$

where S_0 is the power spectral density (PSD) of the unsurveyed (apriori) geoid undulation, $A(K)$ is a spectral error term computed on the basis of the geometry and sensor models for the K -th survey, and N is the total number of independent surveys to be considered. The statistics of gravimetric quantities other than the undulation of the geoid are obtained through the use of flat-earth frequency-domain relations.

There are two main outputs of the calculation. They are:

- The statistics of the residual errors in up to ten gravimetric quantities. The user may select any subset of the ten available quantities. Depending on the output options selected (see the section Selection of Outputs below), these statistics may include one-dimensional spectral densities, auto- and crosscovariances, or standard deviations and correlation coefficients.
- A file containing the two-dimensional power spectral density of the postsurvey residual undulation of the geoid. This file, which may be used for subsequent IMPACT runs, can be obtained as an output file only when the parameter MODE satisfies certain restrictions (see the section Selection of Outputs below).

Input Files

The only input file necessarily required for this phase is the control file, in which the TYPE_OF_RUN specification should include the value GRAVITY. If the NUMERIC gravity model is to be used (see below), additional files containing tables of model geoid undulation spectral densities are also required. These files are described in section 2.2.5.

The run options available in the GRAVITY phase are described below. Parameters which may be used to select and/or modify outputs, models for the gravity field, survey geometry, and sensor error models are discussed in detail.

Selection of Gravimetric Quantities

The gravimetric quantities whose error statistics are to be computed and printed may be specified in the variable GRAVERR, which is a vector of type CHARACTER and can accept up to ten values. The available quantities are:

UND	= Undulation of the geoid
NORTHVD	= North deflection of the vertical
EASTVD	= East deflection of the vertical
ANOMALY	= Gravity anomaly
NNGRAD	= North-North gravity gradient
EEGRAD	= East-East gravity gradient
UUGRAD	= Up-Up gravity gradient
NEGRAD	= North-East gravity gradient
NUGRAD	= North-Up gravity gradient
EUGRAD	= East-Up gravity gradient

Any subset of the above strings may be specified in any order. For example, the entry GRAVERR=(ANOMALY,NORTHVD,EASTVD) will compute error statistics for the three quantities in the above list in the order specified; i.e., the power spectral density and covariance matrices will be printed with the (1,1) element representing the gravity anomaly PSD and/or covariance, the (1,2) element would correspond to the cross-spectral density and/or crosscovariance between the gravity anomaly and the north deflection of the vertical, etc. The default value is

GRAVERR=UND, which will compute only the geoid undulation statistics. The GRAVERR specification has no effect on the generation of the output file containing the geoid undulation spectral density which is passed to the IMPACT calculation.

Selection of Outputs

The GRAVITY segment of the program permits a variety of quantities to be computed, depending upon the options selected by the user. These options are entered via the scalar character string MODE.

The variable MODE will accept any one of four values: PSD, COV, RMS, and AREAMEAN. The default setting is RMS.

A setting of MODE=PSD will cause the program to scan through the two-dimensional frequency domain grid shown in Fig. 2.2-4. The extent of the grid and the number of grid-points are controlled by the parameters SAMPLEA, SAMPLEC, M1, and M2. The input parameters SAMPLEA and SAMPLEC control the highest along track and cross track frequencies, respectively, which are covered by the grid. (See Fig. 2.2-4). Their values are given in nautical miles and both default to 1.0 when MODE=PSD. The parameters M1 and M2 control the number of grid points in the along track and cross track directions respectively. Their values default to 100 when MODE=PSD. The frequency range scanned and the density of the grid points in each direction may be controlled by overriding the default values of SAMPLEA, SAMPLEC, M1, and M2. The resultant array of residual geoid undulation spectral densities is written to the file GRAVFILE. If a file-name has been assigned to GRAVFILE in the control input, the file is kept after completion of the run, otherwise the file is deleted.

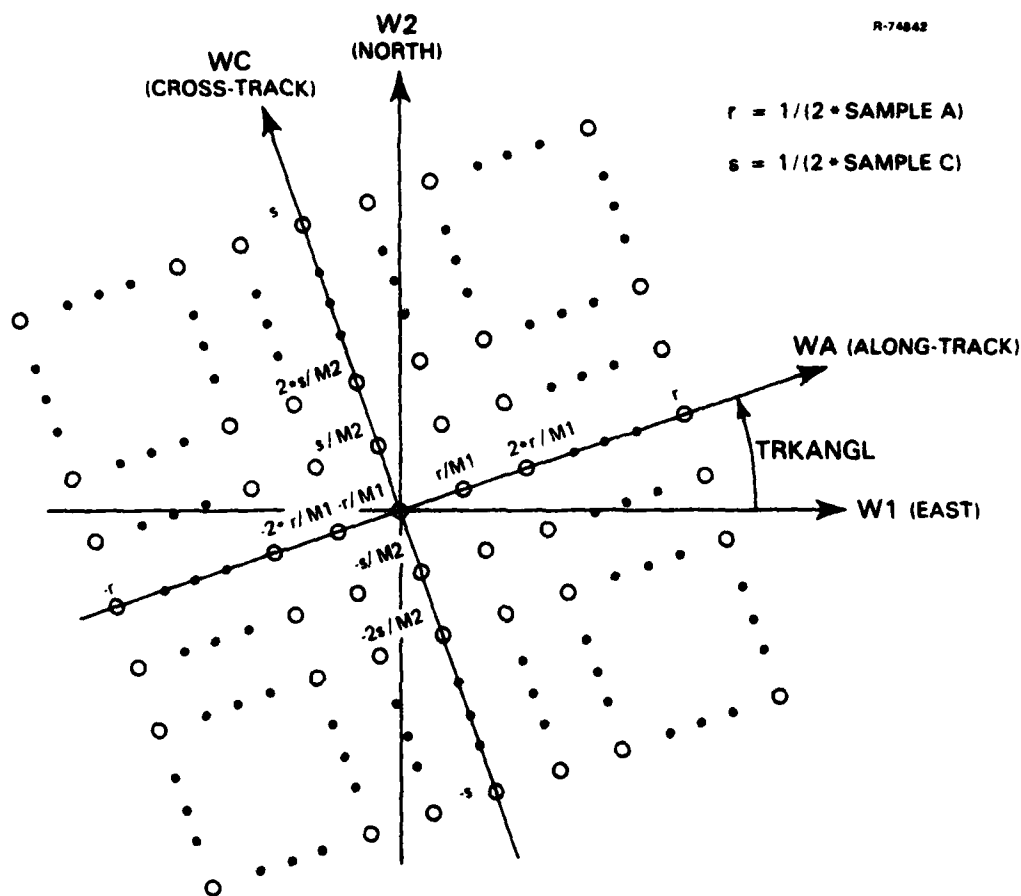


Figure 2.2-4 Frequency Domain Grid for Evaluation of Residuals

In addition, under MODE=PSD the program will use the residual geoid undulation spectral density to compute, at each grid point, the two-dimensional spectral density matrix of the gravimetric quantities specified in the vector GRAVERR. These matrices are integrated in the crosstrack direction to produce a one-dimensional spectral density matrix in the direction specified by the parameter TRKANGL (along track direction measured counter clockwise from east). The resulting densities

are then printed and written onto the file PLOTFILE if a file-name has been specified for this parameter in the control input.

A setting of MODE=COV will do all the above, but in addition will compute approximations to the auto- and cross-covariances of the gravity residuals using a mixed-radix FFT algorithm on the one-dimensional spectral densities to compute their Fourier transforms. The zero-shift component of this array is extracted and printed as the overall covariance matrix of the gravimetric quantities selected. The covariance functions generated by the above procedure are also printed. The files GRAVFILE and PLOTFILE generated by this option are identical to those generated for MODE=PSD, except that PLOTFILE contains the covariance and crosscovariance functions in addition to the spectral densities. Saving of either the file GRAVFILE or the file PLOTFILE is possible only with the settings MODE=PSD and MODE=COV.

A setting of MODE=RMS is used to compute the root-mean-square values, standard deviations, and correlation coefficients of point values of the postsurvey residuals in all gravimetric quantities listed in GRAVERR. The implementation of the MODE=RMS option is dictated by the fact that the grid used for the computations is uniformly spaced in the frequency domain. To obtain appropriate coverage of the frequency plane with a single grid such as that of Fig. 2.2-4 would require extremely large values for the parameters M1 and M2. Since storage requirements and computation time grow as the product of M1 and M2, use of a single grid is not a practical alternative.

To avoid this problem, the RMS mode of operation effectively divides the frequency domain into three concentric square regions as shown in Fig. 2.2-5, of which the innermost region is integrated on a finely spaced grid, the second on a coarser

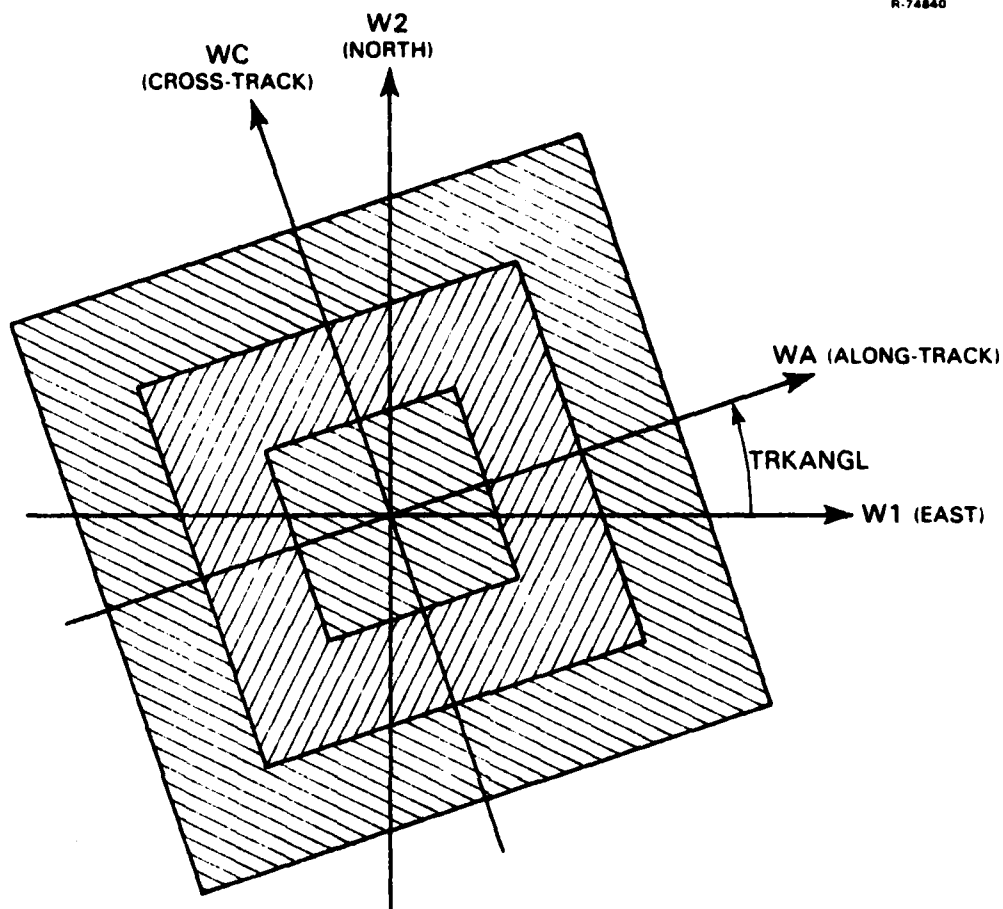


Figure 2.2-5. Frequency Domain Grids for Multiple Scans

grid, and the outermost on the most widely spaced grid. This is accomplished by performing a total of five passes through the procedure described above for the MODE=COV option. A single pass is made through the central low-frequency region using the fine grid spacing, and the computed gravimetric covariance contribution from integrating over this region is saved. The contribution to the covariance obtained from the intermediate-frequency region is computed by performing two more passes with the intermediate grid spacing, one including both the intermediate and low-frequency regions, and the second including only the low-frequency region; the difference in the gravimetric covariances obtained from these two integrations provides

the contribution of the intermediate-frequency region only. A similar two-pass procedure is used to obtain the contribution from the high-frequency region only, these scans being performed using the coarsest grid spacing. The sum of the contributions from all three regions to the gravimetric covariance provides total covariances corresponding to integration over the entire relevant frequency range.

The frequency range and grid spacing of an individual pass are normally controlled by the input parameters SAMPLEA, SAMPLEC, M1, and M2. For the series of concentric scans described above, values of these quantities have been precomputed and are fixed in the program. The RMS option will automatically use these predetermined constants for each pass. Attempts to override these values in the control file will be ignored. The values of SAMPLEA, SAMPLEC, M1, and M2 associated with each of the five scans are listed in Table 2.2-1. As indicated in the table, the range of frequencies covered by the high-frequency scan is doubled for cases in which the selected gravimetric quantities include gravity gradients; this is because the gradients are one order higher derivatives of the potential than the other quantities, and so may produce non-negligible contributions at higher frequencies. Printed output from the RMS option consists of covariances, standard deviations, and correlation coefficients of the residuals in the gravimetric quantities listed in GRAVERR.

Note that if the TYPE_OF_RUN specification also includes the IMPACT phase, the parameter MODE must be set to RMS. Any other specification for MODE is overridden by the program and a warning message is printed.

TABLE 2.2-1
 PREDETERMINED VALUE OF INTEGRATION CONTROL
 PARAMETERS FOR THE RMS AND AREAMEAN MODES

PASS DESCRIPTION	SAMPLEA, SAMPLEC	M1,M2
Low frequency finest grid	94.5000	50
Intermediate frequency intermediate grid	8.4208	50
Low frequency intermediate grid	105.259	4
High frequency coarsest grid (for MODE=RMS runs including gradients)	0.3752	100
High frequency coarsest grid (for all other cases)	0.7504	50
Intermediate frequency coarsest grid	9.3796	4

The IMPACT calculation will be performed after each of the five scans, and the five computed impact covariance contributions are combined in the same way as the gravimetric covariances to yield the total impact covariance. Because each scan after the first rewinds and rewrites the file GRAVFILE, the option to save GRAVFILE for subsequent IMPACT runs is not available in the RMS mode, since the file remaining at the end of the run would correspond to the last scan only. Recommendations on setting GRAVITY phase input parameters for the purpose of saving GRAVFILE for future use in IMPACT runs are given in section 2.2.3.

A setting of `MODE=AREAMEAN` is used to compute statistics of spatial averages of the selected gravimetric quantities. In this mode, the program will not generate the file `GRAVFILE` for the calculation of impact errors, since in the evaluation of spatial averages, geoid undulation spectral density values at different frequencies are not weighted in the same manner. The spatial averages are assumed to be taken over square regions whose size is determined by the input parameter `AREASIZE` (the value of which is given in $\widehat{\text{min}}$). In other respects, the computation resembles a `MODE=RMS` run; the spectral density of the spatial average residual errors is integrated over each of the three frequency regions, and the covariances, standard deviations, and correlations of the residuals in the spatially averaged gravimetric quantities are printed. The inclusion of gravity gradients among the quantities whose statistics are to be computed does not double the size of the frequency domain scanned in an `AREAMEAN` run, as it does in a `RMS` run.

If the `SENSITIVITY` option is not used and `AREASIZE` is not specified in the control input file, `MODE=AREAMEAN` will cause the program to evaluate successively the statistics of the $5 \widehat{\text{min}}$, $15 \widehat{\text{min}}$, 1 deg and 5 deg means of all gravimetric quantities listed in the vector `GRAVERR`. If the `SENSITIVITY` option is not used but a value has been assigned to `AREASIZE`, only the statistics of `AREASIZE` $\widehat{\text{min}}$ means will be produced. When the `SENSITIVITY` option is used, `SENSITIVITY` must equal `AREAMEAN` for the computation of the residuals in spatially averaged quantities. In this case, `AREASIZE` defaults to the single value of $60 \widehat{\text{min}}$ (1 deg means) unless a different value is entered for it in the control input file.

Plotting Options

Plot generation by `MULTISENS` is requested by setting the parameter `PLOT`, a character-string vector whose values

indicate the specific plots to be generated. The disposition of MULTISENS plots is controlled by the input parameter PLOTFILE, a character-string scalar which accepts an output filename as a value.

If PLOTFILE is set to a filename, no graphic plots are generated in the MULTISENS run; instead, the plot information is written to the filename specified, and the interactive program MULTILOT can be used subsequently to view and print the plots, as well as modify scales. The use of MULTILOT is documented separately in section 2.4.

If no value is entered for PLOTFILE, the graphics are generated in the MULTISENS run. In this case, for a batch run the plots are directed to the printer. If the program is run at the terminal the plots will be constructed on the graphics display screen, and the user will be prompted for optional modifications to the plot and hardcopy generation. If the graphics terminal is allocated to another user when the program is run, the screen display will not appear; however, the program will execute as if the plot was being displayed. Valid responses to the prompts (including hardcopy generation) will be executed, but the user will be unable to see the graphics prior to printing.

If the PLOT parameter is not set, or if TYPE_OF_RUN does not include the GRAVITY phase, no plots will be generated. PLOT is a character-string vector which can accept subsets of seven values; these values are: PSD, COH, COV, COR, 3-D, CONTOUR, and SENS. Not all plot options can be selected in the same run. The limitations are as follows. For a sensitivity run only PLOT=SENS may be used. For runs not using the sensitivity option the MODE parameter must be set to either PSD or COV. When MODE=PSD the vector PLOT may be assigned any

values from PSD, 3-D, and CONTOUR. When MODE=COV, PLOT can contain any number of values from PSD, COH, COV, COR, 3-D, and CONTOUR. The various options are described below.

- PLOT=SENS This option generates plots of the dependent variables against the independent variable of the sensitivity run. Sensitivity plots are spline-interpolated, using the IMSL procedure ICSICU. For SENSITIVITY=IMPACT or for SENSITIVITY=RMS with IMPACT included in TYPE OF RUN, the dependent variables plotted are the standard deviations of the selected gravimetric quantities, in addition to the down-range and crossrange standard deviations and the CEP. For SENSITIVITY=AREAMEAN, or for SENSITIVITY=RMS with no IMPACT phase, only the gravimetric standard deviations are plotted. Default scales, unless interactively modified, are linear in both variables with the units given on the plots.
- PLOT=PSD This produces plots of the alongtrack spectral densities of the residual errors in each of the selected gravimetric quantities. The scales default to logarithmic in both directions (zero frequency is not shown).
- PLOT=COH This produces plots of the alongtrack coherence of residual errors between pairs of the selected gravimetric quantities. The default scale is linear for the ordinates and logarithmic for the abscissas.
- PLOT=COV This produces plots of the alongtrack autocovariance functions of the residual errors in the selected gravimetric quantities. The scales default to linear in both variables.

PLOT=COR This produces plots of alongtrack crosscorrelations of the residual errors between pairs of the selected gravimetric quantities. The scales default to linear in both variables.

PLOT=3-D This produces a perspective plot of the spectral density of geoid undulation residuals on a two-dimensional east and north frequency domain. In the east direction, this domain ranges from zero to the maximum alongtrack frequency (as computed from SAMPLEA) and in the north direction it ranges from minus to plus the maximum crosstrack frequency (as computed from SAMPLEC). The number of grid points in the east and north directions may be specified as M1PLOT and M2PLOT respectively; the grid points are then indexed to range from zero to M1PLOT in the east direction, and from -M2PLOT to M2PLOT in the north direction. Both M1PLOT and M2PLOT default to 50. The scales are linear on the frequency axes and logarithmic on the vertical axis. The scales cannot be changed, but the viewing angle may be varied interactively.

PLOT=CONTOUR This produces a contour equivalent of the 3-D plot; it may not be altered interactively. The parameters M1PLOT and M2PLOT also control the number of grid points generated for this plot.

If the program is run in batch form and no PLOTFILE filename is included in the control input, only those plots indicated by the vector PLOT will be printed using the default scales. When PLOTFILE is specified in the control input, the file will contain information to generate all possible plots available under the MODE or SENSITIVITY options in effect,

using MULTILOT. In this case the vector PLOT must specify at least one admissible option compatible with the MODE and SENSITIVITY settings.

If MULTISENS is run at a terminal and plotting options are desired, PLOT must be given at least one admissible value. The user will then be prompted for all possible options during execution. Note that no plots will be displayed in this case if a filename has been assigned to PLOTFILE.

Gravity Model Selection

MULTISENS allows for several possibilities in the description of the unsurveyed gravity field. Three analytic gravity models are included. There is also the option of using a numeric model which requires external files supplied by the user. In addition, there is a stub for attaching a FORTRAN subroutine written by the user defining the gravity field model. A stationary gravity field model is specified in MULTISENS by the two-dimensional spectral density of the undulation of the geoid. Spectral densities, covariances, and crosscovariances of all other gravimetric quantities are obtained from this two-dimensional density through the use of algebraic relations in the frequency domain.

The gravity model to be used is determined by the user in the control input file by setting the character-string scalar parameter MODEL equal to one of the five values: BASELINE, ACTIVE, AWN, NUMERIC, and USER. The default setting is BASELINE.

Both BASELINE and ACTIVE field models are members of the same class of models. They are sums of two independent

third-order isotropic Markov terms (Ref. 2). Each Markov term is determined by two parameters: variance and characteristic distance. Therefore, the BASELINE and ACTIVE models each contain four parameters, the differences between the two models being reflected in the values of these parameters. The ACTIVE model, as its name indicates, corresponds to an active gravity field. Its parameters were obtained by fitting to data in the Bonin Trench. The BASELINE model represents a somewhat milder gravity field. Its parameters were determined from data in the North Atlantic. The parameters of these models are:

- SIGMN12 Variance (in units of meters squared) of the undulation of the geoid associated with the first third-order Markov term. Defaults are 2.666438375 for the BASELINE model and 9.367056530 for the ACTIVE model. When combined with the values of BETAN1 given below, these numbers yield deflections of the vertical with standard deviations of 7.0 $\overline{\text{sec}}$ for the BASELINE model and 16.4 $\overline{\text{sec}}$ for the ACTIVE model.
- SIGMN22 Variance (in units of meters squared) of the undulation of the geoid associated with the second third-order Markov term. Defaults are 87.06737555 for the BASELINE model and 111.9648140 for the ACTIVE model. When combined with the values of BETAN2 given below, these numbers yield deflections of the vertical with standard deviations of 3.0 $\overline{\text{sec}}$ for the BASELINE model and 3.6 $\overline{\text{sec}}$ for the ACTIVE model.
- BETAN1 Inverse characteristic distance (in units of inverse meters) of the first third-order Markov term. Defaults are 0.000036 for the BASELINE model and 0.0000449964 for the ACTIVE model. The corresponding characteristic distances are 15 nautical miles for the BASELINE model and 12 nm for the ACTIVE model.
- BETAN2 Inverse characteristic distance (in units of inverse meters) of the second third-order Markov term. Defaults are 2.7×10^{-6} for the

BASELINE model and 2.856914×10^{-6} for the ACTIVE model. The corresponding characteristic distances are 200 nm for the BASELINE model and 189 nm for the ACTIVE model.

All these parameters are declared REAL. The values of SIGMN12 and SIGMN22 must be greater than or equal to zero while those of BETAN1 and BETAN2 must be strictly positive.

The AWN (Attenuated White Noise) model contains ten different parameters. It corresponds to a fit to a global data set (Ref. 3). The model parameters are fixed in the program and cannot be modified by the user. The model corresponds to a smooth gravity field rich in long wavelength energy content but having little energy at high frequencies.

The NUMERIC model requires that the user supply one, two, or three input files. Filenames are entered via the vector character parameter USERFILE in a statement such as

USERFILE = (filenamea, filenameb)

Each file must contain geoid undulation spectral density values tabulated on a uniform grid of east and north frequencies. The program will use a bilinear interpolator on the logarithm of the grid point values to determine spectral density values between grid points. The format for these files is described in section 2.2.5. If MODE=PSD or MODE=COV, only the first filename listed for USERFILE is used; other entries in userfile are ignored. Multiple files will be used only for the MODE=RMS and MODE=AREAMEAN options previously discussed. In this case the program will use the first member of the USERFILE in evaluating contributions from the innermost region of Fig. 2.2-5. The second member is used for the intermediate grid and the third for the high frequency grid. If only one

element is specified for USERFILE the program will use the same filename for the other two components. If two members are specified, they are assigned to the innermost and intermediate region computations in the order in which they are listed. In this case the second filename is also used for the outer region. If the region being analyzed is larger than the frequency-domain region covered by the contents of the file being used, the program will zero the model spectral density outside the range of values contained in the file. Therefore special care is recommended in ensuring that the frequency ranges of the file(s) are compatible with the ranges corresponding to the parameters in Table 2.2-1.

The units of the tabulated values of the two-dimensional power spectral density of the undulation of the geoid are assumed to be $m^2/(\text{cycle}/m)^2$. If different units are used, the variable USDFACT may be assigned a value in the control input to convert the spectral density values into the appropriate units. All tabulated values are multiplied by the variable USDFACT which defaults to 1.

If the MODEL=USER option is selected, the user will be expected to provide and link into the program a FORTRAN subroutine USRFUNC which returns the two-dimensional geoid undulation spectral density as a function of east and north frequency values. Details of the USRFUNC calling sequence are provided in section 2.2.6. The version of USRFUNC supplied with the program simply generates an error message and terminates execution.

Survey Selection

The surveys to be considered in evaluating the post-survey gravity error statistics are specified in the input parameter SURVEY. This is a character string vector which can

accept up to five values; the user may select no more than one survey descriptor from each of the following five groups:

- For the first satellite radar altimeter survey: ALT1
- For the second satellite radar altimeter survey: ALT2
- For gravimeter surveys: GRAVSHIP or GRAVLAND
- For satellite-to-satellite Doppler surveys: SST
- For airborne gradiometer surveys: DRAPER, DRAPER, BELL, BELLC, GOAL, or GRAD.

Thus, for example, the specification

SURVEY = (ALT1, ALT2, DRAPER)

is correct, but

SURVEY = (ALT1, DRAPER, GOAL)

is not correct because two survey types from the last group have been included.

If the SURVEY specification is omitted from the input, the statistics of the unsurveyed quantities listed in GRAVERR will be computed.

The descriptors GRAVSHIP and GRAVLAND indicate ship-based and land-based gravimeter surveys respectively. Of the gradiometer descriptors, BELL and BELLC indicate the Bell gradiometer without and with carouselling, respectively; DRAPER and DRAPER indicate the Draper Laboratory gradiometer without

and with carouselling, respectively. The survey type GOAL assumes a one-Eotvos gradiometer. GRAD indicates a nonstandard gradiometer whose red and white noise levels may be defined by the user. Error models for the standard gradiometers are described in detail in Ref. 4.

A detailed description of the input parameters associated with each of the possible surveys is given below. These parameters describe both the survey geometry and the sensor error models.

Satellite Radar Altimeter Survey Parameters

Each satellite altimeter survey is modeled as a uniform pattern of ascending and descending subsatellite ground tracks, with measurements spaced uniformly along each track. Values of the input parameters describing this pattern and the instrument's performance may be included in the control file. Unspecified variable values default to those applicable to the GEOS-3 and SEASAT-1 missions for the ALT1 and ALT2 surveys respectively.

Parameters describing the ALT1 survey are all real scalars. They are:

- | | |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ORBINC | Inclination in degrees of the satellite orbit. This parameter must lie between the absolute value of parameter EL (the mean latitude of the region under analysis), and 180 minus the absolute value of EL; it defaults to a value of 115. |
| HEITALT | Altitude in meters of the satellite above the surface. This parameter must be positive, and defaults to a value of 8×10^5 (800 km). |

TRKSP Distance in nautical miles between the equatorial crossings of the ground tracks, for both ascending and descending nodes of the satellite. This value must be positive, and defaults to 30.

SAMPALT Time in seconds between successive altimeter measurements. This value must be positive, and defaults to 0.1.

CA White-noise level in meters squared per measurement of the altimeter. This value must be positive, and defaults to 0.36.

ALTVAR Variance of the altimeter bias in meters squared. This value must be positive, and defaults to 0.25.

ALAM Alongtrack irverse standard deviation of the bias model, in inverse meters. This value must be positive, and defaults to 10^{-6} .

Parameters describing the ALT2 survey are all real scalars. They are:

ORBINCP Inclination in degrees of the satellite orbit. This parameter must lie between the absolute value of parameter EL (the mean latitude of the region under analysis), and 180 minus the absolute value of EL; it defaults to a value of 108.

HEITALTP Altitude in meters of the satellite above the surface. This parameter must be positive, and defaults to a value of 8×10^5 (800 km).

TRKSPP Distance in nautical miles between the equatorial crossings of the ground tracks, for both ascending and descending nodes of the satellite. This value must be positive, and defaults to 80.

SAMPALTP	Time in seconds between successive altimeter measurements. This value must be positive, and defaults to 0.1.
CAP	White noise level in meters squared per measurement of the altimeter. This value must be positive, and defaults to 0.01.
ALTVARP	Variance of the altimeter bias in meters squared. This value must be positive, and defaults to 0.25.
ALAMP	Alongtrack inverse standard deviation of the bias model, in inverse meters. This value must be positive, and defaults to 10^{-6} .

In addition to the above parameters, the oceanographic effects for both altimeter surveys can be controlled through the parameters SIGMAC2 and BETAC. These parameters are described below under the next heading.

Gravimeter Survey Parameters

The gravimeter surveys are modeled as patterns of uniformly spaced east-west tracks, with measurements spaced at equal intervals along each track. The input parameters for either survey are listed below; they are real scalars, except where otherwise indicated.

SE	The data spacing in nautical miles in the east direction (i.e., along the tracks of the survey ship in the case of GRAVSHIP). This value must be positive, and defaults to 0.25 for the GRAVSHIP survey, and 81 (150 km) for the GRAVLAND survey.
SN	The data spacing in nautical miles in the north direction (i.e., the distance between the tracks of

the survey ship in the case of GRAVSHIP). This value must be positive, and defaults to 6 for the GRAVSHIP survey, and to 81 (150 km) for the GRAVLAND survey.

- CG White noise measurement error level, in $(\text{m/sec}^2)^2$. This value must be positive, and defaults to 10^{-12} (0.1 mgal rms) for the GRAVSHIP survey and 9×10^{-10} (3.0 mgal rms) for the GRAVLAND survey. This is the only measurement error term used in the GRAVLAND survey and should include errors of reduction to the geoid. Measurement error sources for the GRAVSHIP survey consist of instrument noise (controlled by CG), Eotvos correction errors (controlled by QQ and EOTVOSW) and ocean-current induced sea surface height (controlled by SIGMAC2 and BETAC).
- QQ Root-mean-square uncorrelated error in the Eotvos correction, in mgal per measurement. This value must be positive, and defaults to 0.75.
- EOTVOSW A logical switch to determine whether the Eotvos correction error terms are to be included in the calculation. It defaults to .TRUE. for the GRAVSHIP survey, and .FALSE. for GRAVLAND. The user may override this default for GRAVSHIP only.
- FULFUNC An integer switch to determine whether alongtrack (east) aliasing terms are to be included in the calculation. A value of zero omits the terms, a value other than zero includes them. The default is zero for GRAVSHIP and 1 for GRAVLAND.
- GRAVXTENT The upper bound in nautical miles for wavelengths to be included in modeling the ship survey. If the

value is zero or negative, there will be no upper bound on the wavelengths included. This parameter defaults to 150 for the GRAVSHIP survey, and -10 for GRAVLAND.

- SIGMAC2 The variance in meters squared of the uncorrected ocean current induced sea-surface height. It must be nonnegative and defaults to 0.36 (60 cm rms).
- BETAC The inverse characteristic distance in inverse meters for the third-order Markov model associated with the ocean current induced sea-surface height. It must be positive and defaults to 2.3809524×10^{-5} (the characteristic distance is 42 km and the correlation distance is approximately 122 km).

Satellite-to-Satellite Doppler Parameters

The satellite-to-satellite Doppler coverage is modeled as a uniform pattern of ascending and descending ground tracks of the lower satellite, similar to the pattern of altimeter coverage. The range-rate measurements take place between this lower satellite and the geostationary relay satellite. The input parameters modifying the SST survey are:

- LOORBINC Orbital inclination of the low satellite (deg). This parameter must lie between the absolute value of parameter EL (the mean latitude of the region under analysis), and 180 minus the absolute value of EL; it defaults to a value of 86.
- LOHEIGHT Altitude in kilometers of low satellite above ground. This parameter must be positive, and defaults to 150.

SSTTRKSP Distance in nautical miles between the equatorial crossings of the lower satellite's ground tracks. This parameter must be positive, and defaults to 30.

SSTSP Time between successive Doppler measurements (sec). This parameter must be positive, and defaults to 10.

HIHEIGHT Altitude in meters of the geostationary satellite above ground. This parameter must be positive, and defaults to 3.5786×10^7 .

SSTLONG Longitude of estimation region relative to the position of the geostationary satellite (deg). The default is zero.

SSTNOISE Root-mean-square white noise level of the range-rate measurements, in micrometers per second. This parameter must be positive, and defaults to 100.

SSTFUNC Integer switch to indicate whether full aliasing is to be included in the computation. A value of zero permits a simplified aliasing calculation, while all other values generate the more complex model. The default is 0.

Airborne Gradiometer Survey Parameters

The various airborne gradiometer surveys are modeled as a uniform pattern of east-west parallel tracks, with measurements at equal intervals along them. The gradiometer survey parameters are:

GRADSP Distance between tracks, in kilometers. This parameter must be positive, and defaults to 10.

SAMPINT Time in seconds between samples. This parameter must be positive, and defaults to 10.

HEIGHT Height of aircraft above ground, in meters. This parameter must be positive, and defaults to 6096 (20,000 ft).

SPEED Speed of aircraft, in km/hour. This parameter must be positive, and defaults to 555.6 (300 knots).

GRADXTENT The longest wavelength in nautical miles which is to be included in modeling the survey. If the value is zero or negative, there no upper bound on the wavelengths included. This parameter defaults to 1500.

GRADFUNC An integer switch to indicate whether full aliasing is to be included in the computation. If GRADFUNC = 0 a simplified aliasing computation is used. All other values use the more complex model. The default is 1.

SWGRAD(3) A three-vector of logical switches, which activate the Z, Y, and X components of the gradiometer triad respectively. If one of the gradiometer surveys is selected via the SURVEY parameter, but none of these switches is explicitly set to .TRUE. by the control stream, the program will set all three to .TRUE. and all gradiometer components will be active. However if the user explicitly sets to .TRUE. a subset of these switches, only that subset will be active.

GRADROT A logical switch which controls whether the umbrella geometry is to be used for the instrument. For the Draper gradiometer surveys, this parameter defaults to .TRUE. and cannot be overridden; for all other gradiometer survey types, it defaults to .FALSE. but can be overridden by the user.

TABLE 2.2-2
GRADIOMETER SURVEY PARAMETERS

SURVEY	RDNSE	WHTNSE
DRAPER	2×10^{-7} (all components)	2.3 (all components)
BELL	7.7×10^{-6} (all components)	650 (first two components), 300 (last four components)
DRAPERC	0 (all components)	2.3 (all components)
BELLC	0 (all components)	650 (first two components), 300 (last four components)
GOAL	0 (all components)	10 (all components)

RDNSE(6), WHTNSE(6) Vectors of coefficients for red and white noise levels (see Ref. 4).

The units of these coefficients are E^2/Hz for RDNSE and E^2/Hz for WHTNSE, where E is the Eotvos unit. For all survey types except GRAD, these vectors are set by the program and cannot be overridden. For the GRAD survey, they default to 10^{30} and should be overridden by the user. The override values must be positive. Settings used for the other surveys are shown in Table 2.2-2.

Note that the BELL gradiometer triad white noise levels include linear and rotational vibration sensitivity effects aside from the instrument's self-noise. Vibrationally induced errors are taken to be the same at all aircraft altitudes. None of the other built-in gradiometer error models contains these effects.

Additional optional input parameters for the GRAVITY phase:

TRKANGL Angle in deg with respect to east
(see Fig. 2.2-4) for definition of
the alongtrack direction in the
computation of the one-dimensional

spectral densities and covariances. Its value defaults to zero. When used in an IMPACT run with a value different from zero, the results approximate the miss statistics for a trajectory whose bearing from north is that of the original trajectory used to create the inflight transfer function minus the value of TRKANGL. The approximation relates only to the effects of the rotation of the earth.

- ALTITUDE** Postsurvey gravimetric error statistics may be computed at any height above the earth's surface. The ALTITUDE parameter is used to select the desired height. ALTITUDE is measured in meters above the surface; it must be nonnegative, and defaults to zero. Note that the undulation error spectrum written to the GRAVFILE file for use in the IMPACT calculation is always computed at the surface, so that the ALTITUDE parameter will have no effect on the impact errors. For that reason it cannot be used as the independent variable in an impact sensitivity run.
- EL** Mean latitude of the region in which the gravity field is being estimated. This parameter is expressed in deg, and defaults to zero. Its absolute value must be such that the region lies within the latitudes covered by the applicable satellites, if any of the ALT1, ALT2, or SST surveys are selected. (See documentation on parameters ORBINC, ORBINCP, and SSTORBINC.)
- GRIDSAVE** For runs in modes PSD or COV, it is possible to save computer time (losing some accuracy in the computations) by using a more widely spaced crosstrack grid spacing for large alongtrack frequency values, since the spectral density function is expected to vary slowly at these frequencies. The parameter GRIDSAVE indicates the fraction of alongtrack

frequency values which are to be integrated using the grid spacing indicated by the M2 and SAMPLEC settings; the remaining alongtrack frequency values (at the high-frequency end of the spectrum) will be integrated using a grid spacing four times wider. For example, given the (partial) input:

MODE=PSD, M1=100, M2=100, GRIDSAVE=0.6

the program will integrate each of the first 61 values of the alongtrack spectral density using 100 crosstrack grid points; the remaining 40 alongtrack frequency values will be integrated using 25 crosstrack gridpoints spaced four times further apart. The parameter GRIDSAVE is real, and must lie between 0.5 and 1 inclusive. It defaults to 1, and may be overridden only for MODE=PSD or COV. Note that if a GRAVFILE file is being saved for future IMPACT runs, the value of GRIDSAVE for the GRAVITY phase must be set to 1.

JPRINT

Debug print level for the GRAVITY phase, assuming values of 0, 1, or 2. The default level is zero, which echoes the input stream and prints the final results. A setting of 1 produces a printout of all the applicable run parameters, plus a listing of the integrated gravimetric spectral density at each alongtrack frequency gridpoint. A setting of 2 produces, in addition, a listing of the undulation spectral density and the major terms contributing to it at each grid point in the two-dimensional frequency domain.

As an additional function for this parameter, setting it to a negative value will cause the program to perform initialization only, and then halt; this can be used to check the validity of a control stream without executing it.

2.2.3 Running the IMPACT phase

The impact phase is used to evaluate the statistics of miss associated with a given survey and trajectory. If both the GRAVITY and IMPACT phases are included in a single run, the GRAVITY phase will write temporary files of residual geoid undulation spectral densities. The GRAVFILE parameter should not be specified in the input since the file cannot be saved, for reasons discussed in section 2.2.2 under the heading Selection of Outputs.

When the IMPACT phase is to be run using a file generated by the GRAVITY phase in an earlier run, the GRAVFILE parameter must be used to indicate the filename. This option allows the user to obtain impact miss statistics for the same survey but for different trajectories. However, this requires that there be one MULTISENS run for each trajectory, using the same GRAVFILE in the multiple runs. In order to specify the residual gravity field, the procedure followed in a single MULTISENS run, including both GRAVITY and IMPACT, can be imitated. This requires the production of five separate GRAVFILE files with five different runs of MULTISENS using MODE=PSD or MODE=COV and with the values of SAMPLEA, SAMPLEC, M1, and M2 as given in Table 2.2-1. The results of the five IMPACT runs must then be combined in the same way as the gravimetric covariance contributions.

Alternatively, a single GRAVFILE file may be used.
The choice of values

SAMPLEA = SAMPLEC = 6.75
M1 = M2 = 100

in the GRAVITY run which produces GRAVFILE yields IMPACT results which in most cases differ by less than two percent from the full five-scan computation.

The IMPACT phase also needs as input the inflight transfer function file generated by the TRANSFER phase. The TRANSFER phase may be included in the same run, or the file may have been saved from an earlier run. If both TRANSFER and IMPACT are included in the same run, omission of the TRANSFILE parameter will cause the program to pass a temporary file between the two phases and to delete this file at the end of the run. When TRANSFILE is specified in such a run the file will be retained after completion of the run. This is in contrast to GRAVFILE, which cannot be retained after a run including both GRAVITY and IMPACT.

Only one input parameter applies to the IMPACT phase; this is the real scalar WAVELONG, which indicates the maximum wavelength to be included in the evaluation of miss statistics. Its units are nautical miles. This parameter must be positive, and defaults to 2700.

2.2.4 Sensitivity Runs

The input character scalar parameters SENSITIVITY and VARIABLE and the real vector parameter VALUE may be set by the user to cause the program to perform a sensitivity study. The program will conduct a series of runs for which the variable indicated in the parameter VARIABLE will sequentially assume each of the values listed in the vector VALUE. The program can then tabulate and plot the values of the computed error statistics against those of the independent variable selected. SENSITIVITY may be set to any one of the three values RMS, IMPACT, and AREAMEAN. These values are used to indicate the

dependent variable in the sensitivity study. (Note that a sensitivity run can also be indicated by entering a value for the VARIABLE parameter, as discussed below.)

Setting SENSITIVITY=RMS will provide the sensitivity of the statistics of the point values of the residuals in the gravimetric quantities listed in GRAVERR. It requires or forces the MODE parameter to the value RMS.

SENSITIVITY=IMPACT provides sensitivities of the statistics of both point value postsurvey residuals and impact miss to the independent variable. This option also requires or forces MODE to the value RMS and in addition adds the option IMPACT to the TYPE_OF_RUN specification if it was not included in the control input. Note that an inflight transfer function file is needed for such a run. This file may be precomputed or, alternatively, may be produced in the same run by including the execution of the TRANSFER phase in TYPE_OF_RUN.

SENSITIVITY=AREAMEAN will force the MODE setting to AREAMEAN and will generate a sensitivity study of the statistics of the residuals in spatially averaged gravimetric quantities. Only gravimetric statistics are available in this mode; inclusion of the IMPACT option in the TYPE_OF_RUN specification will generate an error message and terminate the program.

The parameter VARIABLE may assume any one of the following values:

- For all survey options: ALTITUDE, AREASIZE, EL, TRKANGL. (Note that ALTITUDE is valid only in a non-IMPACT run, since all IMPACT runs would produce identical miss statistics. Also, VARIABLE=AREASIZE is valid only in SENSITIVITY=AREAMEAN runs.)

- For runs which include the ALT1 survey:
ALAM, ALTVAR, BETAC, CA, HEITALT, ORBINC,
SAMPALT, SIGMAC2, TRKSP.
- For runs which include the ALT2 survey:
ALAMP, ALTVARP, BETAC, CAP, HEITALTP,
ORBINC, SAMPALTP, SIGMAC2, TRKSPP.
- For runs which include the SST survey:
LOHEIGHT, LOORBINC, SSTLONG, SSTNOISE,
SSTSP, SSTTRKSP.
- For runs which include the GRAVLAND survey:
CG, GRAVXTENT, SE, SN.
- For runs which include the GRAVSHIP survey:
BETAC, CG, GRAVXTENT, QQ, SE, SIGMAC2,
SN.
- For runs which include any one of the
gradiometer surveys: GRADSP, GRADXTENT,
HEIGHT, SAMPINT, SPEED.

If the input parameter VARIABLE is set, but SENSITIVITY has not been assigned a value in the control input file, SENSITIVITY=IMPACT is assumed.

A maximum of 20 and a minimum of three values must be entered in the vector VALUE. The number of values entered will determine the number of points to be computed on the sensitivity curve. Their order is immaterial but each of the values has to satisfy the numerical constraints active on the values of the variable indicated by VARIABLE.

In a sensitivity run, any value assigned directly to the independent variable by the control file will be ignored; for example, given the control input:

```
TYPE OF RUN = (GRAVITY,IMPACT)  TRANSFILE=TRANS.DAT
SURVEY = (ALT1,GRAVSHIP)
SENSITIVITY=IMPACT              VARIABLE=TRKSP
VALUE=(10.E0,20.E0,40.E0,60.E0,80.E0,90.E0)
TRKSP=50.E0;
```

the program will assign, in successive calculations, values of 10, 20, 40, 60, 80, and 90 nautical miles to the variable TRKSP, and the specification TRKSP=50.E0 will have no effect.

2.2.5 File Format Requirements

There are four files which may be required as input by the phases of the program: a trajectory file for the evaluation of the inflight transfer function in the TRANSFER phase, files describing the NUMERIC gravity model option used in the GRAVITY phase, the geoid undulation error spectral density file produced by the GRAVITY phase and used by the IMPACT phase, and the inflight transfer function file read by the IMPACT phase. The formats of these files are described below.

Trajectory File

The standard trajectory file consists of a series of unformatted records, each corresponding to one time point on the trajectory. Each record consists of ten double precision floating point words, in the sequence: TIME, POS(3), VEL(3), ACC(3). The values of TIME should be in seconds from launch; the three vectors following represent the position, velocity, and specific force at this instant in the flight, and should be expressed in MKS units. The last three entries in each record, ACC(3), are ignored by the program since the error equations (based on a linearization about the nominal trajectory) do not involve specific forces. The velocity vector is used only for the determination of stepsizes in the propagation of the solutions of the differential equations.

The coordinate system for the vectors should be inertial and earth-centered, with the first two axes on the equatorial

plane pointed at the Greenwich meridian and the Greenwich meridian plus 90 degrees, and with the third axis directed towards the North pole, respectively, at the time of launch. The file should contain as many records as needed to define the trajectory from launch to impact, including records corresponding to the launch and impact times. The records should be in nondecreasing order of TIME.

USERFILE Files

Each of the undulation spectral density files used to define the NUMERIC gravity model contains an unformatted header record, followed by a series of unformatted data records.

The header record contains four variables: N1, N2, R1, and R2, which are defined as follows:

N1 is an INTEGER*4 variable which indicates the number of data records to follow. The number of data records will be N1+1, which may be indexed from zero to N1.

N2 is an INTEGER*4 variable which indicates the length of each of the data records to follow. Each data record will contain a vector of $2(N2)+1$ REAL*4 elements, which may be indexed from -N2 to N2.

R1 is a REAL*4 variable which indicates the maximum frequency (in radians per meter) covered by the table in the east direction.

R2 is a REAL*4 variable which indicates the maximum frequency (in radians per meter) covered by the table in the north direction.

Each of the data records which follow contains a vector of REAL*4 values of the undulation spectral density for a fixed east frequency, and for equally spaced north frequency values ranging from -R2 to R2. The east frequencies associated with each data record range in equal intervals from zero to R1,

beginning with the zero-frequency record. Thus if the records are indexed from zero to $N1$ and the data values on each record are indexed from $-N2$ to $N2$ as described above, the J -th value on the I -th record will correspond to an east frequency of $I \times R1 / N1$ and a north frequency of $J \times R2 / N2$. Only the nonnegative east frequency values need be supplied, since the value associated with frequencies $W1$ and $W2$ must be the same as that associated with frequencies $-W1$ and $-W2$.

Geoid Undulation Error Spectral Density File

The undulation spectral density errors are written by the GRAVITY phase either to a temporary file or to the filename entered in the GRAVFILE parameter of the input stream. (For `MODE=RMS` or `AREAMEAN` or for sensitivity runs, the file is written several times, each time destroying the previous version.) The file is unformatted and consists of a header record followed by a series of data records.

The header record contains five variables, in the order: `DATE`, `M1`, `M2`, `SAMPLEA`, and `SAMPLEC`, where `DATE` is a `CHARACTER*20` string containing the date and time of creation of the file, `M1` and `M2` are `INTEGER*4` variables corresponding to the input parameters with the same names, and `SAMPLEA` and `SAMPLEC` are `REAL*8` variables corresponding to the input parameters with the same name.

The header is followed by $M1+1$ data records, indexed from zero to $M1$; each data record consists of two `INTEGER*4` variables $N1$ and $N2$, followed by a vector of $2(N2)+1$ `REAL*8` values. The integer $N1$ is simply the record number, and has values from zero to $M1$; $N2$ is the record length indicator, and can be used to read the record using the statement:

READ (IGRAV) N1,N2, (REC(J),J=-N2,N2)

Normally N2 is equal to M2; they may differ, however, if the parameter GRIDSAVE is set to a value less than 1. (Such a file is not suitable for running the IMPACT phase.) In general, the value indexed J in the record indexed I contains the geoid undulation spectral density value for frequencies WA alongtrack and WC crosstrack, where:

$$WA = \pi I / [(MPERNM)(SAMPLEA)(M1)]$$

$$WC = \pi J / [(MPERNM)(SAMPLEC)(N2)]$$

where N2 is the record length indicator of the Ith record and MPERNM is the number of meters in a nautical mile (1852). The units of WA and WC are in radians per meter, and those of the spectral density values are in $m^2/(\text{cycles}/m)^2$.

TRANSFILE File

The computed inflight transfer function is written to an output file whose name is specified as the TRANSFILE parameter in the control input. If the TRANSFILE parameter is missing from the control input, a temporary file is created, which is deleted at the end of the run. The file consists of a single unformatted record, of the form:

NF, F0, (((G(I,J,K,L),I=1,2),J=1,NF),K=1,NF),L=1,2)

where NF is an integer matrix dimension (equal to NFM1+1), F0 is the double precision reciprocal of the input parameter LAMBDA0 (converted to inverse meters), and G is a single precision complex inflight transfer function table, which is dimensioned (2,NF,NF,2). The index I indicates whether north frequencies are positive (I=1) or negative (I=2). The values

of J and K, respectively, loop over the east and north frequencies, and the index L is associated with downrange miss (L=1) and crossrange miss (L=2).

2.2.6 Interfaces for User-Written Subroutines

There are two subroutines in the program which are designed so that the user may replace them to suit a particular application. The first of these is GETTRAJ, whose replacement will enable the TRANSFER phase to use an input trajectory file in other than the standard format (which is described in section 2.2.5). The second is USRFUNC, which will be called in the GRAVITY phase to provide undulation spectral density values as a function of east and north frequency if MODEL=USER is specified in the input; this enables the user to run with a gravity model other than those supplied with the program.

GETTRAJ is a subroutine used to open, read, and close the input trajectory file. Its calling sequence is:

```
CALL GETTRAJ (ITRAJ,TRAJFILE, FLAG,TIME,POS,VEL)
```

and the arguments are defined as follows:

ITRAJ is the FORTRAN unit number assigned to the trajectory file. The subroutine should not change the value of ITRAJ, but should use it in the OPEN, READ, and CLOSE statements of the program. It should be declared INTEGER*4.

TRAJFILE is the filename of the input trajectory file. The calling program will set this value according to the TRAJFILE specification in the input stream. The subroutine should not change this parameter, but should use it in the OPEN statement for the trajectory file. It should be declared CHARACTER*(*).

FLAG is used as both an input and output argument. Its type is INTEGER*4.

On entry to the subroutine, FLAG indicates the function to be performed on this call; for FLAG=0 the subroutine should open the file, for FLAG=1 the subroutine should close the file, and for FLAG=2 the subroutine should read the next trajectory record and return the contents in the last three arguments.

Before returning from the subroutine, the argument FLAG should be set to one of two values: 0 (zero) if the I/O function requested was performed correctly, and 10 if an end-of-file was encountered on a read operation (i.e., when the input value of FLAG was 2).

TIME is a REAL*8 scalar output argument which is used only for a read operation; i.e., when the input value of FLAG is 2. It should be filled with the time value read from TRAJFILE. Units are seconds from launch.

POS is a REAL*8 three-vector output argument, which is used only for a read operation. It should be filled with the position vector read from TRAJFILE, converted if necessary to an earth-centered inertial Cartesian system with the three axes oriented to Greenwich, Greenwich + 90 deg, and the North pole at time of launch. Units are meters.

VEL is a REAL*8 three-vector output argument, which is used only for a read operation. It should be filled with the velocity vector read from TRAJFILE, converted if necessary to the same coordinates as POS. Units are meters/second.

The standard version of GETTRAJ may be used as a guide in constructing a substitute.

The function USRFUNC will be invoked by function FFUNC for runs in which the MODEL=USER option is selected. It should be defined as:

```
REAL*8 FUNCTION USRFUNC (W1,W2)
```

where the arguments W1 and W2 are REAL*8 scalars containing the east and north frequency values respectively, in units of radians/meter. The value returned should be the modeled undulation spectral density at those frequency values, in units of $m^2/(cycles/m)^2$.

Either of the standard functions MARKOV2 and AWN may be used as a guide in constructing a USRFUNC module.

2.3 RUNNING THE MULTIJOB PROGRAM

The MULTIJOB program is an interactive tool to create a job stream for the MULTISENS program. It leads the user through the various options available in MULTISENS using previous inputs to update available options. If a previous selection has made another option unavailable, that other option will not be presented. The program also checks the inputs for consistency and validity. A control input file is created which can automatically be submitted and/or saved under a user specified filename. If the file is saved, it can be submitted as a batch job by the SUBMIT command or the program can be run at a terminal using the execute procedure (@) command. When @ is used as a prefix to a filename (i.e., @FILENAME) the lines of the file are taken to be commands which are to be executed as if they were entered at a terminal. For more information on the execute procedure command the user should consult Volume 2A of the VAX/VMS Reference Manuals. The saved file can then be edited using the EDT editor to make further changes, without rerunning MULTIJOB.

2.3.1 Requirements and Limitations

This section of the user's manual is concerned only with the execution of the MULTIJOB program. Since it is the object of this program to create the control input file for the MULTISENS program, the user should be familiar with the inputs required by MULTISENS. The MULTISENS user's manual is given in section 2.2.

No files are used as input to MULTIJOB; however, since some configurations of MULTISENS require input files, these files should exist prior to the execution of MULTIJOB. MULTIJOB will verify that the files exist, but will not check to see whether the information they contain is in the correct format. The requirements for these files are given in section 2.2

2.3.2 Input Formats

There are two general ways in which the user is prompted for information. The first method involves questions which appear one at a time on the screen, to which the user responds before the next question appears. A sample of this is shown in Fig. 2.3-1.

Delimiter characters are available to separate the responses to questions which call for more than one entry. These delimiters are ' '(blank), ',', ';', '/', '(', ')', '!', or '>'. The '!' and '>' are special delimiters which are discussed in more detail below. Since the semicolon is used as a delimiter it cannot be used as part of a filename specification. If a version number is required in a filename it should be separated from the rest of the filename by a period. Two or more delimiters appearing together (e.g. ',;'), are treated as

a single delimiter. The '!' character is used to end the current input line. Any characters entered on the same line after a '!' will be ignored and therefore can be used as a comment. The '>' delimiter is similar to the '!' in that the current input line is ended but has the added feature of allowing the input to continue on the next line. Any characters entered after the '>' on the same line will be ignored. If the prompt requires only one answer and more are entered, separated by valid delimiters, only the first value will be used. In multiple-entry questions, second and subsequent appearances of the same value will be ignored. Examples of various input line formats are illustrated in Fig 2.3-1. As shown, the group of lowercase x's is ignored and does not constitute part of the input.

The types of surveys available are: (ALT2, ALT1, GRAVSHIP, GRAVLAND,
 SST, DRAPER, DRAPERC, BELL,
 BELLC, GOAL, and GRAD)

Note: The default value is no survey.

Enter full name of survey, no abbreviations accepted

Any combinations of surveys are acceptable with the following exceptions

1. GRAVLAND and GRAVSHIP are mutually exclusive
2. Only one type of gradiometer allowed (DRAPER, DRAPERC, BELL, BELLC, GOAL, or GRAD)

Enter as many as desired: SST,ALT1; ALT2 (GRAVLAND>
DRAPER ! xxxxxxxxxxxxx

What gravity quantities do you want included?

(UNDULATION, NORTHVD, EASTVD, ANOMALY, NNGRAD, EEGRAD,
----- UUGRAD, NEGRAD, NUGRAD, and EUGRAD)

Enter up to 10 quantities: NORTHVD, EASTVD > xxxxxxxxx
ANOMALY(UUGRAD)EEGRAD>

EASTVD, EUGRAD ! THE SECOND EASTVD WILL BE IGNORED AS WELL AS THIS COMMENT

Figure 2.3-1 Samples of Individual Question Inputs

The second input format consists of entering values to a table of input parameters. As the display develops on the screen, the variable, its units, and its current value will appear one line at a time. If the current value is satisfactory a blank line should be entered by pressing the RETURN key <CR>. The next variable will then appear for inspection. If a different value is desired, the value should be entered at the current cursor position in the NEW VALUE column with no more than 20 characters; the length of the underlining for the column is 20 characters. The delimiter characters mentioned above are not active for table input. After all the variables for the section have appeared, the user will be asked if any further changes are desired. If a YES is entered, the display will reappear with any new values replacing the old in the current value column. The display will again develop line by line, with the user able to make further changes to the variables. The program will continue when the user enters a NO to the further changes prompt. If after a number of changes the user wishes to see the original values, HELP should be entered in the new value column. This will display the original values for the parameters in the current table. Figure 2.3-2 shows what a completed display looks like with some changes entered.

When a filename is entered, the name must include all qualifiers to identify the file uniquely. A complete file specification has the following format:

device:[directory]filename.type.version

The punctuation marks (colons, brackets, periods) are required to separate the various components of the file specification. If the input file is on the same directory as the user, only the filename and type need to be specified. The default filetype is DAT, and if no version number is given, the file

This section lets you change the current values of the input parameters which affect the SST survey. The input variable will appear with its current value displayed. If no changes are desired enter a carriage return <CR>. If a new value is desired, enter the new value and a <CR>.

VARIABLE -----	UNITS -----	CURRENT VALUE -----	NEW VALUE -----
LOHEIGHT	KM	150.0	
LOORBINC	Deg	86.0	
SSTFUNC		0	
SSTLONG	Deg	0.0	
SSTNOISE	MicroM/SEC	100.0	110.0
SSTSP	SEC	10.0	
SSTTRKSP	NM	30.0	

Do you wish to make any changes? (YES or NO)

Figure 2.3-2 Sample of Table Input Parameter Prompting

with the highest version number is used. Semicolons should not be used to separate version numbers from the rest of the filename since the semicolon is used as an input delimiter in this program. Its use would cause the program to ignore the version number. Volume 2A of the VAX/VMS Reference Manuals contains a complete description of valid file specifications. If the file is required as an input to MULTISENS, it is checked for existence. If the file is an output of MULTISENS, the name is checked only for a valid file specification.

In most places, abbreviations of three or more letters will be accepted. Exceptions to this are filenames and survey specifications.

When running the program, the user can enter the following special commands at the beginning of any input line.

- QUIT - This command will terminate the program with no control input file created.
- BACK - The program will reset back to a previous prompt so that previously entered inputs may be modified. Successive BACK commands will eventually bring the user back to the beginning of the program. The BACK command resets most of the variables except for those displayed in the table form of Fig. 2.3-2, which retain their previous values.
- HELP - This command will print out a brief message to explain in more detail what needs to be entered. It is more useful in obtaining a description of the appropriate syntax than in obtaining a description of the options available. For a description of the options, the MULTISENS user's manual should be consulted (section 2.2).

If a default answer is applicable at any point, the default value is shown underlined in the list of acceptable values. Not all inputs have a default value assigned to them. In some cases the default value implies none; for example, no survey in the type of survey question. If there is no default value a message is printed to that effect. For the questions that are to be answered with a YES or a NO, the default is always NO. The only acceptable entries for YES or NO questions are YES, NO, BACK, QUIT, HELP, <CR>, or beginning substrings of these words. Any other inputs will cause the program to reprompt the user.

2.3.3 Program Execution

The program is executed by entering the command:

RUN MULTIJOB

After the command is entered, the screen will clear and display an initial message giving some general information. At this point the user is asked whether the input verification mode is desired. This mode echoes back what the user has entered. The user is asked whether this information is correct before the program will proceed. An example of the verification mode output is shown in Figure 2.3-3. If the user is not satisfied with the entry, the prompt will reappear for the user to enter another value. If the user desires this mode, a YES should be entered. If the faster nonverification mode is desired, the user can enter a NO or RETURN. The validity check on the input parameters is always done and does not depend on whether the verification mode is on.

```
What type of run do you want? (TRANSFER, GRAVITY, or IMPACT)
-----

Enter one, two, or all three: TRAN,GRAV,IMP

The types of run you have selected are:
TRANSFER
GRAVITY
IMPACT

Is this correct? (YES or NO)
```

Figure 2.3-3 Sample of Input Verification Mode Responses.

The questions presented from this point on in the program will gather information to be used in constructing the job stream. The first will ask for the type of MULTISENS run the user wants. Valid inputs at this point are:

- TRANSFER - The inflight transfer function is computed.
- GRAVITY - The gravity residuals are computed.
- IMPACT - Downrange and crossrange errors and CEP are computed.

The default value for MULTILOT is a GRAVITY run. Any combination of the three may be entered. From this point on, the program prompts for information dealing with those phases the user has selected in the following order: inflight transfer function, gravity residual analysis, and impact error computation. The phase for which the questions are being asked always appears at the top of the screen.

TRANSFER

If TRANSFER was selected, the next set of questions deals with the inflight transfer function computation. The questioning begins with a table of input parameters which the user can change as described in the input format section above. Next the program asks for a trajectory file name. This file must already exist. There is no default trajectory file; the user must supply one. Finally the user is asked whether the transfer function calculations are to be saved permanently. If so, a filename must be entered since there is no default filename. This file need not already exist as it will be created by MULTISENS.

GRAVITY

The GRAVITY residual questions will next appear if the user has selected GRAVITY. This begins with the selection of a gravity model. The valid models are:

- BASELINE
- ACTIVE
- AWN
- NUMERIC
- USER.

Only one model should be entered with BASELINE being the default value. If the NUMERIC model is selected, the user will be prompted for files containing the model. The contents of these files are specified in sections 2.2 and 2.2.5. Up to three filenames can be entered. If the filenames cannot be entered on a single line, the continuation character > can be used between filenames to continue the input on successive lines. If the USER model is chosen, there are some additional considerations. The USER model requires the inclusion of a routine USRFUNC describing the model. If this routine is not included in the system version of MULTISENS, MULTIJOB will create a control input file which will access the system version of MULTISENS and not the one containing the new USRFUNC. MULTIJOB can still be used to create a job stream; however, it should not be submitted automatically but rather saved. The saved file can then be edited and the RUN MULTISENS line should be changed to run the executable file which contains USRFUNC. A user unfamiliar with the editor should consult Volume 3A of the VAX/VMS Reference Manuals.

The user is then prompted to enter the gravimetric quantities whose statistics are to be computed. Valid quantities are:

- UND - undulation of the geoid
- NORTHVD - north deflection of the vertical
- EASTVD - east deflection of the vertical
- ANOMALY - gravity anomaly
- NNGRAD - north-north gravity gradient
- EEGRAD - east-east gravity gradient
- UUGRAD - up-up gravity gradient

- NEGRAD - north-east gravity gradient
- NUGRAD - north-up gravity gradient
- EUGRAD - east-up gravity gradient

Up to 10 quantities can be entered, separated by valid delimiters, with UND being the default value. The order of the inputs will be retained.

A list of general MULTISENS input variables is then presented in the table form of Figure 2.3-2. After this, the type of survey is to be entered with valid surveys being:

- SST - Satellite to satellite doppler
- ALT1 - First satellite altimeter
- ALT2 - Second satellite altimeter
- GRAVSHIP - Ocean-based gravimeter
- GRAVLAND - Land-based gravimeter
- DRAPER - Draper gradiometer
- DRAPERC - Carouselled Draper gradiometer
- BELL - Bell gradiometer
- BELLC - Carouselled Bell gradiometer
- GOAL - Goal gradiometer
- GRAD - User specified gradiometer

The full survey name must be entered. Abbreviations are not acceptable for survey input. Entering a blank line will give the default value of no surveys. Up to five different surveys may be entered with two restrictions. Only one type of gravimeter survey is allowed; only one type of gradiometer survey is allowed.

If the user has selected an altimeter and/or gravimeter survey, two parameters describing the ocean current model will be displayed in the list format. The user can make changes as described in the input format section above.

If the MULTISENS run is to be a sensitivity run, the user will then be prompted for further information necessary for the run. The first question is to define the type of sensitivity. The valid sensitivities are:

- RMS - Sensitivity statistics of point values are computed.
- AREAMEAN - Sensitivity of spatial averages computed. The user will be further prompted for the AREASIZE parameter. The default is 60.
- IMPACT - Sensitivity of impact error statistics are computed.

Next the user should enter the parameter which is the independent variable in the sensitivity run. The variables available as the independent variable are a subset of all input parameters. The valid sensitivity variables are:

ALAM	CG	LOORBINC	SN
ALAMP	EL	ORBINC	SPEED
ALTITUDE	GRADSP	ORBINCP	SSTLONG
ALTVAR	GRADXTENT	QQ	SSTNOISE
ALTVARP	GRAVXTENT	SAMPALT	SSTSP
AREASIZE	HEIGHT	SAMPALTP	SSTTRKSP
BETAC	HEITALT	SAMPINT	TRKANGL
CA	HEITALTP	SE	TRKSP
CAP	LOHEIGHT	SIGMAC2	TRKSPP

For a specific run, the acceptable variables may be a subset of those listed above, depending on what surveys are included in the run. If the variable entered is not used in the current

setup of the MULTISENS run, a message will inform the user that the variable is not valid for this run and a new one will have to be entered. Once an acceptable variable has been entered, the values for that variable must be entered. They should be separated by any of the delimiters and > used if the input must be continued on the next line. Up to 20 values may be entered but a minimum of three values is required.

If plotted output from the sensitivity run is desired, the user has a choice of having hard copies made during the batch job, or of storing the information in a file to obtain plots later using MULTIPLOT. If the plot information is to be saved, a filename can be entered or the default name TMPPLTMLT.DAT is used. The filename is checked only to verify that it has a valid file specification.

If this is not to be a sensitivity run, the user will be prompted for the type of output for the run. The acceptable modes are:

- PSD - Power spectral density
- COV - Covariance
- RMS - Point values
- AREAMEAN - Area mean values.

Only one value should be entered with RMS being the default value. If AREAMEAN is selected, the user will be further prompted for the area size. The default value is a series of runs that yield the statistics of the 5, 15, 60, and 300 min means. If these are not acceptable, only one value can be entered for the area size prompt.

If either PSD or COV is entered, the user will be allowed to change the integration region parameters (described in section 2.3.2) in the table input format. Also, if plotted output is desired, the user has a choice of having hard copies made during the MULTISENS program or of storing the information in a file. If the information is to be stored, a filename should be entered or the default name TMPPLTMLT.DAT is used. If hard copies are selected, the user will enter the types of plots. Some plots are not available if the mode PSD has been selected. The valid plots are:

- PSD - Power spectral density plots available with a MODE of PSD or COV
- COH - Coherence plots available with a MODE of PSD or COV
- COV - Covariance plots available only with a MODE of COV
- COR - Correlation plots available only with a MODE of COV
- 3-D - Surface plots available with a MODE of PSD or COV
- CONTOUR - Contour plots available with a MODE of PSD or COV.

Depending on the parameter MODE, up to 6 values can be entered. The defaults are COV when MODE=COV and PSD when MODE=PSD.

Following the selection of plotting options, the last GRAVITY phase inputs are entered. These consist of the parameters describing the geometry and sensor error models for the various surveys previously selected by the user. The parameters are presented in the table input format. Any changes can be made as described in the section on input formats (section 2.3.2). Also, if GRAD has been selected, the user will be

required to enter the values for both the red and white noise parameters.

IMPACT

The IMPACT error computation questions are next. These questions are asked only if IMPACT was included in TYPE_OF_RUN or a SENSITIVITY of IMPACT was selected. Depending on the current program setup, the user may be asked for a file containing the inflight transfer function table (TRANSFILE) and/or a file containing the geoid undulation error spectrum (GRAVFILE). If requested, these files must already exist. The parameters for the IMPACT phase will then be presented in the table input format.

JOB SUBMITTAL

The final section of the program deals with the actual creation of the job stream. The user is asked whether the job is to be submitted and whether the control input file is to be saved. The control input file created does not have to be submitted in order to be saved. If the file is saved, it can subsequently be edited to incorporate changes in the job stream. If the file is to be saved, a filename should be entered or the default TMPMLT.COM is used. If no filetype is specified, the default COM is assumed. The filename is checked only for a valid file specification. If the job is to be submitted, a message stating that it has been submitted will be printed. The user is then asked whether the MULTIJOB program is to be restarted in order to create another control input file. If not, the program will terminate. If the program is restarted, the input variables displayed in the table input format are not reset to their original values but contain the values that were used in the previous run. The original values can be inspected by entering HELP in the NEW VALUE column.

If the file created by this program is saved, it can be submitted as a batch job via the SUBMIT command. The file can also be run at the terminal with the execute procedure (@) command. For more help with the @ command the user should consult Volume 2A of the VAX/VMS Reference Manuals.

2.3.4 Error Messages

The MULTIJOB program contains several error traps to detect and flag some common errors. The two major types of errors detected are:

- Input errors - These occur when an undecipherable word or number has been entered. These are flagged as invalid options or nonnumeric values and the user is prompted to reenter the values.
- Validity errors - These occur when a value for an input parameter is out of the valid range for that variable. A message will be printed and the user prompted to enter a new value.

Invalid file names and nonexistent files are included in the input errors. Each of these is flagged with the messages:

*** Error in locating file. Check spelling or include path name if file is in another directory.

*** File specification error. Check for illegal character.

The first may occur if the filename is misspelled, or if the file is in another directory and the path name was not included. The second message occurs when an illegal character is contained in the file name or when the file specification is not in the

correct format. The user should consult Volume 2A of the VAX/VMS Reference Manuals for further information on file specification.

Another type of input error is an invalid or undecipherable entry. These are flagged with a message of the form:

XXYYZZ is invalid, reenter

If this should occur, only that one invalid value need be reentered. Similarly, if the input is not a valid number, the message

*** Variable TRKANGL has a nonnumeric value 10.R2
Reenter value:

will be printed. When this is encountered, the user should reenter the corrected value.

Among the validity errors are those detected by MULTISENS. These include errors of conflict of parameters and values out of range. The first includes such errors as trying to get a sensitivity of AREAMEAN when IMPACT has already been selected. This would produce the message:

Cannot have IMPACT with a SENSITIVITY of AREAMEAN

The second type, value out of range, would produce a message similar to:

*** Variable ALTITUDE has an invalid value of -200
Valid values are: ALTITUDE => 0.0
Reenter value:

The user need only reenter an acceptable value for the variable. No default values exist at this time.

2.4 RUNNING THE MULTILOT PROGRAM

MULTILOT is an interactive program used to display graphical output on the Lexidata color graphics terminal, based on information stored during a MULTISENS run. MULTILOT allows the user to change scales on the plots and select which ones to present. It cannot change MULTISENS parameters or recompute the plots.

2.4.1 Preprocessing Requirements and Limitations

MULTILOT requires as input a file containing the plot information. This file must have already been created by the MULTISENS program. Information stored in this file tells what options were used in the MULTISENS run and what plots will be available during the execution of MULTILOT.

Since MULTILOT also requires the use of the Lexidata color graphics terminal, the user should check that the graphics terminal is available prior to running the program. Also, the toggle switches located on the trackball unit should be in the OFF position. The program will execute even if the graphics terminal is not available, but no plots will be generated on the screen. The plot menu will appear and its functions, except for the zoom, will be valid. The user can then generate hard copies if so desired.

2.4.2 Program Execution

MULTILOT is executed by entering the command

RUN MULTILOT

The user will first be prompted for a file name containing the plot information previously created by the MULTISENS program. The default filename is TMPPLTMLT.DAT.

After the file name has been entered, the screen will clear and information concerning the MULTISENS run that created the file will appear at the top of the VT100 screen. This information will remain at the top of the screen while the current plot file is used. It will also appear on the graphics terminal under the plots, except when contour or surface plots are being displayed. The prompt

Enter command:

will then appear. Whenever this prompt is on the screen, the user has the choice of which plots are to be displayed. Entering HELP will present a list of acceptable commands and a brief description of their use. The available commands are different for the two general categories of plots: sensitivity or gravimetric statistics. The sensitivity plots display impact errors, point values, or spatial average sensitivities to the independent variable. The statistics plots can display covariances, correlations, power spectral densities, coherences, or two-dimensional power spectral densities as surface or contour plots, depending on the parameters used in the MULTISENS run.

There are three main categories of commands that the user can enter. These are

- General commands available during both sensitivity and statistical plotting

- Sensitivity plot commands
- Statistical plot commands.

A description of each of the commands available in each of these categories follows. If an invalid command is entered the program will reprompt the user for another command. The general commands available are:

- QUIT - Program execution is terminated.
- BACK - This will reset the program back to a previous location so that different options can be selected. A BACK entered at the "Enter command: " prompt will allow the user to enter a new file by returning to the enter file name prompt.
- HELP - This command will print out a brief message to explain in more detail some aspects of the current question. This command is not present at all locations.

Commands which are available only for sensitivity plotting are:

- IMPACT - The downrange, crossrange, and CEP sensitivity curves are displayed. This is valid only if MULTISENS was run with SENSITIVITY = IMPACT.
- RMS - The point value sensitivity curves are plotted. This is valid only if MULTISENS was run with SENSITIVITY = RMS or SENSITIVITY = IMPACT.
- AREAMEAN - The sensitivity of spatial average curves is displayed. It is valid only if MULTISENS was run with SENSITIVITY = AREAMEAN.

The commands available only for the gravimetric statistical plots are:

COVARIANCE - The covariances of the gravimetric quantities specified in the MULTISENS run are displayed. This requires that MODE = COV in the MULTISENS run.

CORRELATION - The correlations of the gravimetric quantities specified in the MULTISENS run are plotted. This requires that MODE = COV in the MULTISENS run.

PSD - The power spectral densities of the gravimetric quantities specified in the MULTISENS run are displayed.

COHERENCE - The coherences of the gravimetric quantities specified in the MULTISENS run are plotted.

SURFACE/3-D - Either command will create a surface plot of the two-dimensional power spectral density generated by MULTISENS.

CONTOUR - This command produces a contour plot of the two-dimensional power spectral density generated by MULTISENS.

All the plotting commands, except for CONTOUR and SURFACE/3-D, will display the following menu:

<CR>/CLEAR	- to clear screen and continue
PRINT	- to produce hard copy
ZOOM	- to zoom and scroll
SCALE	- to change axis scaling
BACK	- to return to command input
QUIT	- to terminate the program.

The commands in more detail are:

<CR>/CLEAR- This will clear the Lexidata screen. If there is another plot in the series it will be presented, otherwise control will go back to the command input line with the "Enter command: " prompt.

PRINT - A hard copy of the current plot shown on the Lexidata will be printed on the line printer after the program stops.

ZOOM - The user has the ability to expand any area of the plot. After entering ZOOM, the user sets any WHITE switch on the trackball unit to the ON position. The trackball can now be used to position any particular part of the plot on the screen. If a higher magnification is subsequently set, the area expanded will be the upper right corner of the screen. The WHITE switches set the magnification level, with switch E (the first WHITE switch to the left of the BLUE one) having unity magnification and magnification increasing by factors of two with switch A (leftmost WHITE switch) having a magnification factor of 16. When the user is finished with the zoom facility, all switches should be set to their OFF position and the BLUE switch should be toggled to redisplay the plot menu on the VT100.

SCALE - SCALE is entered if the user wishes to change the type of axis (linear or log) and/or the end points of the scale. After SCALE is entered, the user is prompted to specify the type of axis by entering one or two of the following:

XLOG - The x-axis will have a logarithmic scale

XLINER - The x-axis will have a linear scale

YLOG - The y-axis will have a logarithmic scale

YLINER - The y-axis will have a linear scale

Any scale which is not affected by an entered command remains the same. A blank line can be entered if the user does not wish to change the type of axis. The user will next be prompted for the minimum and maximum for each axis. The default

The commands available only for the gravimetric statistical plots are:

COVARIANCE - The covariances of the gravimetric quantities specified in the MULTISENS run are displayed. This requires that MODE = COV in the MULTISENS run.

CORRELATION - The correlations of the gravimetric quantities specified in the MULTISENS run are plotted. This requires that MODE = COV in the MULTISENS run.

PSD - The power spectral densities of the gravimetric quantities specified in the MULTISENS run are displayed.

COHERENCE - The coherences of the gravimetric quantities specified in the MULTISENS run are plotted.

SURFACE/3-D - Either command will create a surface plot of the two-dimensional power spectral density generated by MULTISENS.

CONTOUR - This command produces a contour plot of the two-dimensional power spectral density generated by MULTISENS.

All the plotting commands, except for CONTOUR and SURFACE/3-D, will display the following menu:

<CR>/CLEAR - to clear screen and continue

PRINT - to produce hard copy

ZOOM - to zoom and scroll

SCALE - to change axis scaling

BACK - to return to command input

QUIT - to terminate the program.

value displayed is used if a blank line is entered. If the minimum and maximum for an axis are equal, automatic scaling will be done by the program. The system plotting package will not always use the exact minimum and maximum values as entered as the end points, but the discrepancy will not be significant. If the user changes an axis type to LOG and the current minimum is less than or equal to zero, the minimum is changed to 10^{-8} .

BACK - This command will return the user to the "Enter command:" prompt.

QUIT - This command will terminate the program execution.

For the contour plot, the menu does not contain the SCALE option. For the surface plot, the SCALE option is also not available but in this case it is replaced by an ANGLE option. This lets the user observe the current plot from any viewing angle. The user will be prompted for two angles measured in degrees. The first is an angle in the x-y plane measured counterclockwise from the positive x-axis to the line of sight. The default value for the first plot is -60. The second angle is from the x-y plane to the line of sight. Positive values are above the plane; negative values view from below the plane. The default value for the first plot is 20.

If the user wishes to stop program execution, at any point in the program, QUIT should be entered. If the user wishes to get back to a previous point, the BACK command should be used.

2.4.3 Error Messages

The program has several error traps designed to detect and flag some common errors. If the error is an invalid or undecipherable command, the messages that appear will be of the form:

*** Error in input, retry

Invalid command, retry

If one of these is encountered, the user should check the spelling or make sure the command is valid for this run of the program. The HELP command could be of assistance.

There are two possible errors concerning the input file specified. These will print one of the following messages:

*** Error in opening file FILENAME
Check for misspelling or incorrect path name

*** Error in reading plot file
File possibly not created by MULTISENS

The first will appear if the file specified (FILENAME) cannot be found, an invalid file specification is entered, or invalid characters are included in the filename. The user should check the spelling and/or specify the path name if the file is not in the current directory. The second error message occurs when the program cannot read the file. This could happen if the file was not created by MULTISENS. The user should make sure that the correct filename was entered. When any of the above messages appears on the screen, the user will be re-prompted to enter a filename. If the user wishes to terminate the program, QUIT should be entered as the filename.

If, during the sensitivity plotting, the user enters a command for which there are no data because MULTISENS did not contain the appropriate option, one of the following messages will appear:

This MULTISENS run did not compute impact sensitivity

This MULTISENS run did not compute sensitivity of
point values

This MULTISENS run did not compute sensitivity of
area means

A warning message which MULTILOT may print is

*** Scale spans 0.0
Log scale changed to linear

This message is generated for a log scale if the axis would contain zero or negative numbers. The scale affected is automatically converted to a linear scale. If the user still wishes a log scale, then the SCALE option on the plot menu should be used and the upper and lower bounds of the log scale changed to include only positive values.

3.

MULTISENS PROGRAM DESCRIPTION

The following sections outline the structure and the major processing routines in the MULTISENS program. Together with the internal documentation in the FORTRAN code itself, they should provide the information necessary for a programmer to maintain or modify the program.

3.1 PROGRAM ORGANIZATION

MULTISENS consists of a main routine and 92 subroutines; it also makes use of the following applications libraries:

- The NAMELIST and interactive query routines contained in UTILLIB.OLB
- The TASC Software Graphics Package
- The IMSL mathematical library.

Of the 92 subroutines in MULTISENS, 19 are also used by the MULTILOT program and 4 are used by the MULTIJOB program; these routines are indicated in Table 3.1-1.

Figs. 3.1-1 through 3.1-4 show the calling structure of MULTISENS. In these figures, calls to the libraries listed above are indicated, but the individual routines within these packages are not shown. The main routine MULTISENS calls a series of routines to read and check the control input; it may then call COMPTRAN to perform the TRANSFER phase of the program, COMPGRAV to perform the GRAVITY phase, and/or INFLIGHT

TABLE 3.1-1
TABLE OF ROUTINES IMPLEMENTED IN MORE THAN ONE PROGRAM

SUBROUTINE	PROGRAMS
APPEND	MULTISENS, MULTILOT
CHGANGL	MULTISENS, MULTILOT
CHGSCALE	MULTISENS, MULTILOT
CHKMMX	MULTISENS, MULTILOT
COMPARE	MULTISENS, MULTILOT, MULTIJOB
GETINFO	MULTISENS, MULTILOT
LXPRMT	MULTISENS, MULTILOT
PARSE	MULTISENS, MULTILOT, MULTIJOB
PLTCOHER	MULTISENS, MULTILOT
PLTCONT	MULTISENS, MULTILOT
PLTCORREL	MULTISENS, MULTILOT
PLTCOVAR	MULTISENS, MULTILOT
PLTIMP	MULTISENS, MULTILOT
PLTPOINTS	MULTISENS, MULTILOT
PLTPOWSP	MULTISENS, MULTILOT
PLTRMS	MULTISENS, MULTILOT
PLTSUR	MULTISENS, MULTILOT
PROMPT	MULTISENS, MULTILOT, MULTIJOB
SIZE	MULTISENS, MULTILOT, MULTIJOB

to perform the IMPACT phase. Because the computation of impact errors may also be included as part of a multiple-scan GRAVITY run, INFLIGHT may also be called from within COMPGRV.

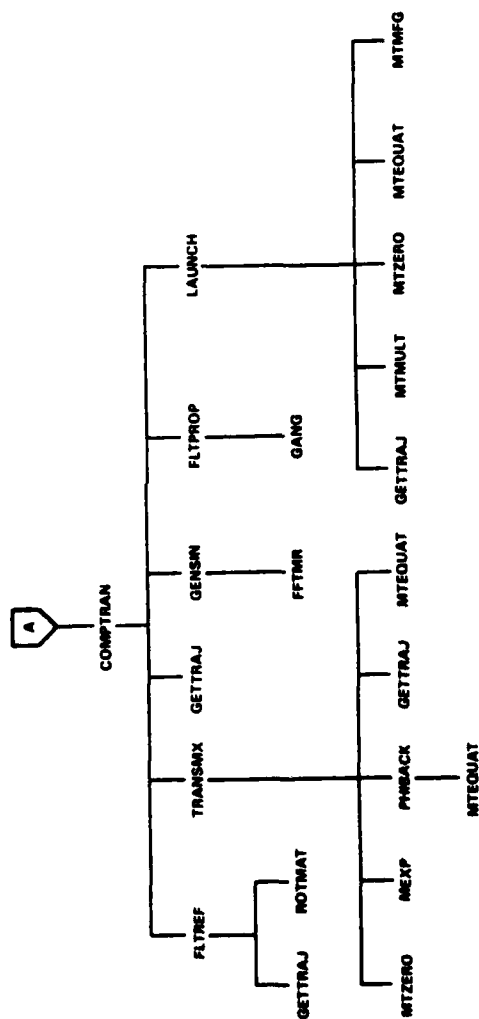
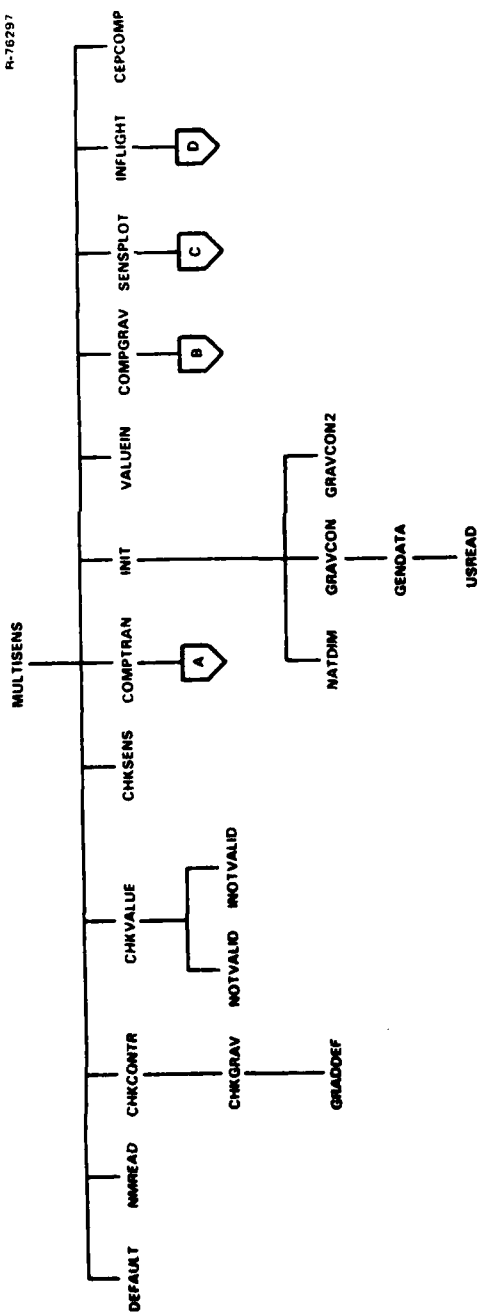


Figure 3.1-1 MULTISENS Calling Tree

Figure 3.1-2 MULTISENS Calling Tree (Continued)



Figure 3.1-3 MULTISENS Calling Tree (Continued)

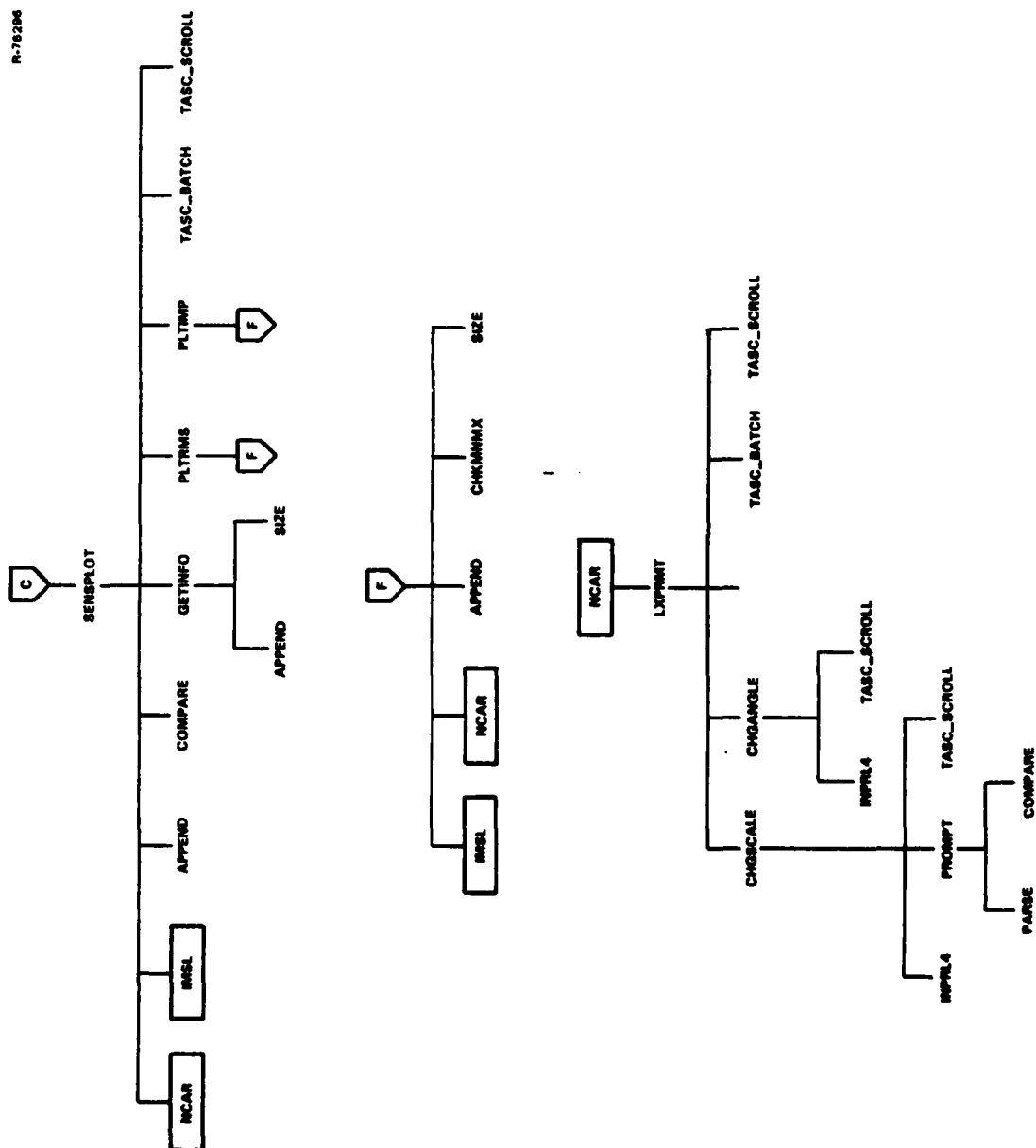


Figure 3.1-4 MULTISENS Calling Tree (Continued)

3.2 MAIN PROGRAM DESCRIPTION

The main program sets up the argument structures for calling the NAMELIST package (code for this is in the included file NMLIST.FOR), and calls the NMREAD subroutine to read the control input; most of the control variables are located in common blocks. The routines CHKCONTR, CHKVALUE, and CHKSENS are used to check the input variables for valid values and internal consistency; if errors are found, the program executes a stop statement, otherwise it executes the phases requested.

The variable COUNT indicates how many times to execute the GRAVITY phase (and possibly the IMPACT phase); it will be set to 1 except in a sensitivity run, in which case it is the number of values entered for the independent variable. For a sensitivity run, the subroutine VALUEIN is used to insert the next value from the list of values into the appropriate variable; an integer containing the address of the variable (obtained from one of the NAMELIST arguments) is passed by value; subroutine VALUEIN treats the argument as if it had been passed by reference, so that the actual variable rather than the address integer is modified.

Common Blocks: WORK, CHARCONTR, INPUTS, TRANSFER, CONTROL, DATABLK, MATSIZE, CONSTANTS

Subprograms called: DEFAULT, NMREAD, CHKCONTR, CHKVALUE, INIT, VALUEIN, COMPGRAV, INFLIGHT, CEPCOMP

3.3 COMMON BLOCK DESCRIPTION

This section describes each of the common blocks used by the program, and lists the variables in each.

CHRCONTR

This common block, described in the included file CHRCONCOM.FOR, contains the character-string input parameters, and a page header constructed from them. The variables are:

NAME	TYPE	DIM	DESCRIPTION
GRAVERR	CHAR*10	10	List of gravimetric quantities
MODE	CHAR*10	-	GRAVITY phase output descriptor
MODEL	CHAR*10	-	Gravity model descriptor
PLOT	CHAR*10	8	Plot option descriptors
SENSITIVITY	CHAR*10	-	Sensitivity run type indicator
SURVEY	CHAR*10	5	Survey model descriptors
TYPE_OF_RUN	CHAR*10	3	Program phase selection
GRAVFILE	CHAR*80	-	Filename for geoid undulation PSD file
TRAJFILE	CHAR*80	-	Filename for input trajectory file
TRANSFILE	CHAR*80	-	Filename for inflight transfer function table
USERFILE	CHAR*80	3	Filenames for NUMERIC model geoid undulation files
PLOTFILE	CHAR*80	-	Filename for output plot file
PAGE_TITLE	CHAR*130	-	Page title for initial parameter printout

CONTROL

This block, defined in the included file CONTRCOM.FOR, contains many of the control variables and logical switches

used by the program. They include some input parameters, and other switches and integers set by character-string input variables; they are arranged as follows.

NAME	TYPE	DIM	DESCRIPTION
INDXOUT	INTEGER*4	10	Indices of gravimetric quantities to be included.
JPRINT	INTEGER*4	-	Debug print level for GRAVITY phase
M1	INTEGER*4	-	Number of alongtrack frequency intervals
M1PLOT	INTEGER*4	-	Number of alongtrack grid points in 3-D or contour plot
M2	INTEGER*4	-	Number of crosstrack frequency intervals
M2PLOT	INTEGER*4	-	Number of crosstrack grid points in 3-D or contour plot
NFIELD	INTEGER*4	-	Number of gravimetric quantities to be included
IFLTER	INTEGER*4	-	FORTTRAN unit number for flat-earth temporary file used in TRANSFER phase
IGRAV	INTEGER*4	-	FORTTRAN unit number for GRAVFILE
IPLOT	INTEGER*4	-	FORTTRAN unit number for PLOTFILE
IPRINT	INTEGER*4	-	FORTTRAN unit number for printout
IREAD	INTEGER*4	-	FORTTRAN unit number for control input
ITRAJ	INTEGER*4	-	FORTTRAN unit number for TRAJFILE

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AFGL-TR-81-0307 F19628-80-C-0078

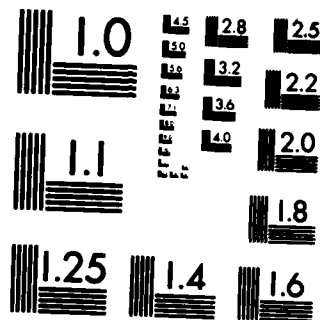
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MICROCOPY RESOLUTION TEST CHART
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IUSER	INTEGER*4	-	FORTTRAN unit number for USERFILE files.
IUSFILE	INTEGER*4	-	Number of USERFILES specified.
IXFER	INTEGER*4	-	FORTTRAN unit number for TRANSFILE
ALTSW	LOGICAL*4	-	ALT1 altimeter survey switch
ALTSWP	LOGICAL*4	-	ALT2 altimeter survey switch
DEBUG	LOGICAL*4	-	Debug printout switch for TRANSFER phase
EOTVOSW	LOGICAL*4	-	Eotvos error switch for gravimeter survey
GRADROT	LOGICAL*4	-	Switch for umbrella gradiometer geometry
GRAVSW	LOGICAL*4	-	Gravimeter survey switch
MEANSW	LOGICAL*4	-	Switch for area-mean gravity statistics
SSTSW	LOGICAL*4	-	SST survey switch
SWGRAD	LOGICAL*4	3	Vector of switches for 3 components of gradiometer survey
USDSW	LOGICAL*4	-	Switch for applying scale factor to NUMERIC model input data
PLT3D	LOGICAL*4	-	Switch for 3-D plot
PLTCNT	LOGICAL*4	-	Switch for contour plot
PLTCOH	LOGICAL*4	-	Switch for coherency plots
PLTCOR	LOGICAL*4	-	Switch for correlation plots
PLTCOV	LOGICAL*4	-	Switch for covariance plots

PLTPSD	LOGICAL*4	-	Switch for power spectrum plots
PLTSENS	LOGICAL*4	-	Switch for sensitivity plots
GFILESAV	LOGICAL*4	-	Switch to retain GRAVFILE at end of run
GRAVITY	LOGICAL*4	-	Switch for GRAVITY phase
IMPACT	LOGICAL*4	-	Switch for IMPACT phase
KEEPFILE	LOGICAL*4	-	Switch to generate GRAVFILE file
PLOTSAV	LOGICAL*4	-	Switch to generate PLOTFILE file
TRANSFER	LOGICAL*4	-	Switch for TRANSFER phase
XFILESAV	LOGICAL*4	-	Switch to retain TRANSFILE at end of run

DATABLK

This block, which is defined in the included file DATABCOM.FOR, contains the data read from the current USERFILE file, which is used to define the NUMERIC gravity model. The scalars define the size and frequency range of the table, and the vector USER_DATA contains the table itself.

NAME	TYPE	DIM	DESCRIPTION
RANG1	REAL*8	-	Max east frequency covered by table
RANG2	REAL*8	-	Max north frequency covered by table
W1STEP	REAL*8	-	Frequency interval in east direction
W2STEP	REAL*8	-	Frequency interval in north direction

NROWS	INTEGER*4	-	Number of east frequency values > 0
NROWLEN	INTEGER*4	-	Number of north frequency values > 0
INCORE	INTEGER*4	-	Number of rows stored in table - should be NROWS+1
MAXCORE	INTEGER*4	-	Number of words in array USER_DATA - should be 131072
USER_DATA	REAL*4	131072	Table of undulation values.

The table USER_DATA should be accessed as a matrix dimensioned (0:NROWS, -NROWLEN:NROWLEN), where element (I,J) contains the undulation spectral density for east frequency value W1STEP*I and north frequency value W2STEP*J. The total number of elements in the matrix must be less than or equal to MAXCORE. Frequency units are radians/meter, and geoid undulation units are meters**2/(cycles/meter)**2.

CONSTANTS

This common block, defined in the included file CONSTCOM.FOR, contains a set of REAL*8 scalar constants computed and used internally by the program. In general they contain evaluated common expressions that occur in the gravity and survey model equations, and are stored here for reasons of computational efficiency. Since they have no significance outside the program, they are not documented in detail here; they are computed and stored in subroutine GRAVCON, and used in the appropriate modeling routines. The variables are all of type REAL*8, and are named, in order:

AMU	AMUP	B	BETAC2	BETAN12
BETAN22	BP	C	COSALF	COSALFP
COSEL	COSTHETA	E11VAL	E11VALP	E31VAL
FCONST1	FCONST2	GCONST	GRADCON1	GRADCON2
LOHEIM	MPERNM	PA	PE	PI
PJ	PN	PP	PU	RANGE1
RANGE2	SINALF	SINALFP	SINTHETA	SSTWHITE
TWALONGC	TWALONGS	TWCROSSC	TWCROSSS	TWMUC
TWMUCP	TWMUS	TWMUSP	WALONG	WCONST
WCONSTP	WCROSS	WE	WE2	WGRADE
WGRADN	WGRDE2	WGRDN2	WL	WLAM
WLAMP	WMAXGRAD2	WMU2	WMU2P	WN2

INPUTS

This common block, defined in the included file INPUTCOM.FOR, contains many of the real and integer input parameters which define the gravity and survey models, as well as a few internal constants. The variables are arranged in alphabetical order, as follows:

NAME	TYPE	DIM	DESCRIPTION
ALAM	REAL*8	-	ALT1 altimeter alongtrack bias inverse standard deviation
ALAMP	REAL*8	-	ALT2 altimeter alongtrack bias inverse standard deviation
ALTITUDE	REAL*8	-	Altitude for gravimetric residuals
ALTVAR	REAL*8	-	Variance of ALT1 altimeter bias
ALTVARP	REAL*8	-	Variance of ALT2 altimeter bias
AREASIZE	REAL*8	-	Size of averaging bin for area-mean statistics

BETAC	REAL*8	- Inverse characteristic distance for dynamic height ocean current model
BETAN1	REAL*8	- Inverse characteristic distance for 1st Markov model term
BETAN2	REAL*8	- Inverse characteristic distance for 2nd Markov model term
CA	REAL*8	- ALT1 altimeter white noise level
CAP	REAL*8	- ALT2 altimeter white noise level
CQ	REAL*8	- Gravimeter white noise level
EL	REAL*8	- Latitude of survey region
FULFUNC	INTEGER*4	- Switch for gravimeter along track aliasing
G	REAL*8	- Mean gravity acceleration (not an input parameter)
GRADFUNC	INTEGER*4	- Gradiometer aliasing switch
GRADSP	REAL*8	- Gradiometer survey track spacing
GRADXTENT	REAL*8	- Maximum wavelength for gradiometer survey
GRAVXTENT	REAL*8	- Maximum wavelength for gravimeter survey
GRIDRAT	REAL*8	- Working value of GRIDSAVE (not an input parameter)
GRIDSAVE	REAL*8	- Proportion of scan to be performed at nominal grid spacing
HEIGHT	REAL*8	- Aircraft altitude for gradiometer survey

HEITALT	REAL*8	-	ALT1 altimeter satellite altitude
HEITALTP	REAL*8	-	ALT2 altimeter satellite altitude
HH	REAL*8	-	mgal/meter conversion constant squared (not an input parameter)
HIHEIGHT	REAL*8	-	Relay satellite altitude for SST survey
LOHEIGHT	REAL*8	-	Low satellite altitude for SST survey
LOORBINC	REAL*8	-	Low satellite inclination for SST survey
ORBINC	REAL*8	-	ALT1 altimeter orbit inclination
ORBINCP	REAL*8	-	ALT2 altimeter orbit inclination
QQ	REAL*8	-	RMS Eotvos error for gravimeter survey
RDNSE	REAL*8	6	Gradiometer red noise parameter array
SAMPALT	REAL*8	-	ALT1 altimeter data interval
SAMPALTP	REAL*8	-	ALT2 altimeter data interval
SAMPINT	REAL*8	-	Data interval for gradiometer survey
SAMPLEA	REAL*8	-	Half shortest alongtrack wavelength
SAMPLEC	REAL*8	-	Half shortest crosstrack wavelength
SE	REAL*8	-	East gravimeter data spacing
SIGMAC2	REAL*8	-	Variance for dynamic height ocean current model

SIGMN12	REAL*8	-	Variance for first 3rd-order Markov undulation model
SIGMN22	REAL*8	-	Variance for second 3rd-order Markov undulation model
SLAM	REAL*8	-	Distance between ALT1 altimeter measurements (not an input parameter)
SLAMP	REAL*8	-	Distance between ALT2 altimeter measurements (not an input parameter)
SN	REAL*8	-	North gravimeter data spacing
SPEED	REAL*8	-	Aircraft speed for gradiometer survey
SSTFUNC	INTEGER*4	-	SST survey aliasing switch
SSTLONG	REAL*8	-	Relay satellite relative longitude for SST survey
SSTNOISE	REAL*8	-	RMS white noise level on SST measurements
SSTSP	REAL*8	-	Time between SST measurements
SSTTRKSP	REAL*8	-	Equator crossing interval for SST survey
TRKANGL	REAL*8	-	Track angle of trajectory relative to east
TRKSP	REAL*8	-	ALT1 altimeter equator-crossing interval
TRKSPP	REAL*8	-	ALT2 altimeter equator-crossing interval
USDFACT	REAL*8	-	Scale factor to be applied to USERFILE data in NUMERIC model
WHTNSE	REAL*8	6	Gradiometer white noise parameter array

MATSIZE

This common block, defined in the included file MTSIZCOM.FOR, contains the dimensions of many of the matrices used internally by the program. This permits the matrices to be passed as arguments without always including the dimensions in the argument list. The variables are set in subroutine MATDIM, and are arranged as follows.

NAME	TYPE	DIM	DESCRIPTION
N_CBUF	INTEGER*4	-	Length of CBUF array used in subroutine FOURIER
N_M1	INTEGER*4	-	East dimension of frequency scan
N_M2	INTEGER*4	-	North dimension of frequency scan
N_N2	INTEGER*4	-	Number of columns in NUMERIC model table
N_OUTSPEC	INTEGER*4	-	Dimension of GRAVFILE output buffer used by subroutine GENSPEC
N_PHI	INTEGER*4	-	Dimension of gravimetric PSDs and covariance matrices
N_PLOTSPC_R	INTEGER*4	-	Number of rows in array for 3-D and contour plots
N_PLOTSPC_C	INTEGER*4	-	Number of columns in array for 3-D and contour plots
N_RAC_R	INTEGER*4	-	Number of rows in array containing gravimetric auto and cross correlations
N_TABLE_R	INTEGER*4	-	Number of rows in NUMERIC model table

TRANSFER

This common block, defined in the included file TRANS.COM.FOR, contains parameters used in the TRANSFER and IMPACT phases. They are arranged as follows.

NAME	TYPE	DIM	DESCRIPTION
CRIT	REAL*8	-	Upward continuation attenuation factor
LAMBDA0	REAL*8	-	Longest non-DC wavelength to include in TRANSFER phase
NFM1	INTEGER*4	-	Number of nonzero table entries
NWAVE	INTEGER*4	-	Number of subdivisions of a wavelength
TFIN	REAL*8	-	Time of impact in seconds from launch
TDEPLOY	REAL*8	-	Time of deployment in seconds from launch
MDEBUG	INTEGER*4	-	Loop index for maximum debug print
WAVELONG	REAL*8	-	Longest wavelength to use in IMPACT phase

CRLABS

This common block contains information concerning the contour plot labels. It is used to communicate this information to the plot package.

NAME	TYPE	DIM	DESCRIPTION
TITLE	CHAR*40	-	Plot title
XTITLE	CHAR*40	-	X-axis label
YTITLE	CHAR*40	-	Y-axis label

CRMNMX

This common block contains the information for the numeric labels on the axes of the contour plot. It is used to communicate this information to the plot package.

NAME	TYPE	DIM	DESCRIPTION
XMIN	REAL*4	-	X-axis minimum value
XMAX	REAL*4	-	X-axis maximum value
YMIN	REAL*4	-	Y-axis minimum value
YMAX	REAL*4	-	Y-axis maximum value
NDEC	INTEGER*4	-	Number of decimal places in numeric labels on plots

CRTICS

This common block contains the information on how the axes tick marks are provided on the contour plot. It is used to communicate this information to the plot package.

NAME	TYPE	DIM	DESCRIPTION
XMAJOR	INTEGER*4	-	Number of major tick marks on X-axis
XMINOR	INTEGER*4	-	Number of minor tick marks between major tick marks on X-axis
YMAJOR	INTEGER*4	-	Number of major tick marks on Y-axis
YMINOR	INTEGER*4	-	Number of minor tick marks between major tick marks on Y-axis

LEXINFO

This common block returns information about the plot back to the program. It is used to communicate plot menu selections between the plot package and the program.

NAME	TYPE	DIM	DESCRIPTION
ISWITCH	INTEGER*4	-	Switch indicating whether Angle or Scale is to be offered (input into plot package). On output it signifies whether the plot is to be redrawn.
LAXIS	INTEGER*4	-	Switch containing the type of axis(used as last argument to DISPLA)
XMIN	REAL*4	-	Minimum value for X-axis
XMAX	REAL*4	-	Maximum value for X-axis
YMIN	REAL*4	-	Minimum value for Y-axis
YMAX	REAL*4	-	Maximum value for Y-axis
ANGH	REAL*4	-	Horizontal viewing angle
ANGV	REAL*4	-	Vertical viewing angle

SRLABS

This common block contains information concerning the surface plot labels. It is used to communicate this information to the plot package.

NAME	TYPE	DIM	DESCRIPTION
TITLE	CHAR*40	-	Plot title
XTITLE	CHAR*40	-	X-axis label
YTITLE	CHAR*40	-	Y-axis label

SRMNMX

This common block contains the information for the numeric labels on the axes of the surface plot. It is used to communicate this information to the plot package.

NAME	TYPE	DIM	DESCRIPTION
XMIN	REAL*4	-	X-axis minimum value
XMAX	REAL*4	-	X-axis maximum value
YMIN	REAL*4	-	Y-axis minimum value
YMAX	REAL*4	-	Y-axis maximum value
NDEC	INTEGER*4	-	Number of decimal places in numeric labels on plots

WORK

This common block has no fixed structure; it is used in a number of routines for temporary array storage in order to conserve memory. It is never used to pass information between subroutines, although arrays defined within it are sometimes passed as arguments in a subroutine call. Its size, as defined in the main program (MULTISENS), is 176000 doublewords (1408000 bytes).

3.4 SUBROUTINE NAMES AND FUNCTIONS

3.4.1 Initialization Routines

CHKCONTR Checks the run control variables for acceptable and consistent values, and issues diagnostics when errors are detected

CHKGRAV	Checks the gravity run descriptors for internal consistency, and issues diagnostics when errors are detected
CHKSENS	Checks the list of independent variable values for duplicates and validity, and issues diagnostics when errors are detected
CHKVALUE	Checks the values of numeric input parameters to ensure that they lie within valid ranges, and issues diagnostics when errors are detected
DEFAULT	Initializes the input variables prior to reading the control stream, setting them either to default run values or to flag values so that overrides can be detected
GENDATA	Reads the user-provided geoid undulation model file(s) and stores the contents in a table for numeric interpolation
GRADDEF	Sets values for the gradiometer white noise and red noise levels according to the gradiometer type specified
GRAVCON2	Sets up a page-header line for the GRAVITY phase printout
INIT	Supervises the initialization of the GRAVITY phase computation
INOTVALID	Prints an error message when an integer parameter is outside its permissible range
MATDIM	Sets up the internal matrix dimensions in a common block, and checks them for consistency
NOTVALID	Prints an error message when a real parameter is outside its permissible range
PRINTINI	Prints the initial values of all the run parameters

3.4.2 Upper-Level Inflight Transfer Function Routines

COMPTRAN	Supervises computation of the inflight transfer function
----------	----------------------------------------------------------

FLTPROP	Computes the inflight transfer function and writes it to a file
FLTREF	Reformats the input trajectory file into flat-earth launch-point coordinates
GETTRAJ	Routine used to open, read, and close the input trajectory file when computing the inflight transfer function. May be replaced by the user to process a nonstandard trajectory file.
LAUNCH	Computes the miss-partial matrix from the launch point

3.4.3 Lower-Level Inflight Transfer Function Routines

GANG	Function which returns a sine or cosine value by performing quadratic interpolation on the pregenerated sine or cosine table
GENSINE	Uses the Fast Fourier Transform to generate tables of sine and cosine functions for interpolation
MEXP	Computes the coefficients used to evaluate the matrix exponential for the state transition matrix of an inertial navigation system
PHIBACK	Uses the transition matrix from time 0 to time T, and the matrix coefficients for the matrix exponential, to compute the transition matrix from time 0 to time T+DT
ROTMAT	Computes the rotation matrix used to transform from earth-fixed to inertial coordinates at a given latitude and longitude
TRANSMX	Generates an array of transition matrices for six by six error equations of a missile trajectory

3.4.4 Upper-Level Gravity Routines

ALTIM	Evaluates the spectral density error contribution for the ALT1 survey
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ALTIM2	Evaluates the spectral density error contribution for the ALT2 survey
COMPGRAV	Supervises computation of the statistics of gravimetric residuals and impact errors for a single set of survey parameters. This routine is called repeatedly for different values of the independent variable in a sensitivity run.
FOURIER	Computes the alongtrack auto- and cross-covariance functions of the gravimetric residuals from their along track spectral densities
GENSPEC	Computes the residual gravity errors as a function of alongtrack and crosstrack frequency, and integrates them across track
GRADMTR	Evaluates the spectral density error contribution of the gradiometer survey
GRAVCON	Computes and stores constants used in the modeling of the various surveys
GRAVMTR	Computes the spectral density error contribution of the gravimeter survey
MVECTOR	Computes the outer product with itself of the vector transfer function from undulation spectral density to the other gravimetric quantities
SPECTRM	Computes the spectral density of the residual geoid undulation error and the gravimetric cross-spectral density at given east and north frequency values
SSTDOP	Evaluates the spectral density error contribution of the satellite-to-satellite Doppler survey

3.4.5 Lower-Level Gravity Routines

AWN	Returns the Attenuated White Noise (AWN) model geoid undulation spectral density (FUNCTION)
-----	---------------------------------------------------------------------------------------------

FFUNC	Returns the geoid undulation spectral density using the appropriate gravity model (FUNCTION)
GFUNC	Returns the power spectral density of the ocean current dynamic height as a function of the Hankel frequency (FUNCTION)
GRAVUNIT	Converts the integrated spectral density matrix at a given alongtrack frequency from metric units to the more commonly used gravimetric units
HFUNC	Returns the survey ship modulation transfer function at a given east frequency value (FUNCTION)
MARKOV2	Returns the undulation spectral density using a third-order Markov model; i.e., BASELINE or ACTIVE (FUNCTION)
MTCORRC	Computes either the RMS values or the RMS values and correlation coefficients from a covariance matrix, and prints them
NOISE	Evaluates the spectral density matrix of the gradiometer measurement errors
PRTCov	Prints the alongtrack gravimetric autocovariances as a function of shift distance
PRTPSD	Prints the alongtrack gravimetric power spectral densities as a function of along track frequency
SCALP	Computes the inner product of two complex six-vectors (COMPLEX FUNCTION)
SQ_NORM	Returns the Euclidean squared norm of a complex six-vector (FUNCTION)
TFGRAV	Returns the square magnitude of the gradiometer transfer function (FUNCTION)
TFSST	Returns the transfer function from geoid undulation to range-rate satellite-to-satellite tracking measurements (FUNCTION)
TVECTOR	Evaluates the vector transfer function from geoid undulation to the airborne gradiometer measurements

USEDATA	Returns the interpolated value of the NUMERIC model geoid undulation spectral density for a given east and north frequency (FUNCTION)
USREAD	Reads a USERFILE provided for the NUMERIC gravity model, and constructs a table of logarithmic values for interpolation
USRFUNC	A stub to be replaced by a user-written function which will return the geoid undulation spectral density at given east and north frequency values (FUNCTION)
VALUEIN	Inserts the next value of the independent variable into the appropriate location for a sensitivity run
WFUNC	Returns the contribution to the spectral density of the geoid undulation errors for the ALT1 survey from ocean current dynamic height errors (FUNCTION)
WFUNCP	Returns the contribution to the spectral density of the geoid undulation errors for the ALT2 survey from ocean current dynamic height errors (FUNCTION)

3.4.6 Upper-Level Impact Computation Routines

CEPCOMP	Computes the downrange and crossrange impact standard deviations and the circular error probable (CEP) from the impact covariance
INFLIGHT	Computes the impact covariance matrix from the geoid undulation error spectral density file and the inflight transfer function file

3.4.7 Lower-Level Impact Computation Routines

BINT	Performs a bilinear interpolation of the inflight transfer function table, returning the interpolated downrange-crossrange vector
INTX	Integrates the contributions to the impact error covariance over the frequency domain

SETCOMP	Computes an array containing the product of the square root of the geoid undulation residual PSD and the interpolated values of the inflight transfer function
SETPOT	Computes an array containing the square root of the geoid undulation residual PSD
SETSUM	Computes an array containing the contribution of each frequency grid point to the impact covariance matrix

3.4.8 Output Processing Routines

CHGANGL	Prompts the user for changes in the viewing angle for a 3-D surface plot
CHGSCALE	Prompts the user for changes in the scale of a two-dimensional plot
CHKMMX	Checks the end values of a logarithmic plot scale; if the range of values includes zero, issues a message and changes the scale to linear
GENMAG	Generates a two-dimensional array of undulation magnitudes on the east-north frequency domain, for use in contour or perspective plots
GETINFO	Uses values stored in common blocks to generate labels for plot annotation
LXPRMT	In an interactive run, issues prompts to the user requesting plot options, and returns the user's selections to the plotting package. In a batch run, returns a request for hard copies of the requested plots. LXPRMT is a replacement for the corresponding routine in the TSGP plot package, and is called from within TSGP.
PLTCOHER	Plots the coherency of the gravimetric error spectra
PLTCONT	Generates the contour plot of the geoid undulation spectral density

PLTCORREL Plots the along track gravimetric auto-and cross correlations

PLTCOVAR Plots the along track gravimetric auto-and cross covariances

PLTGRAV Supervises the interactive plotting of gravimetric errors

PLTIMP Performs sensitivity plots of the downrange and crossrange RMS misses and the CEP against the tabulated values of the independent variable. The plotted curve is spline interpolated.

PLTPOINTS Overlays characters on the sensitivity plot at the points on which the interpolated plots are based. Offsets each character coordinate so that the center of the character lies on the plotted point.

PLTPOWSP Plots the power spectral density of gravimetric residual errors, and the magnitude of the cross-spectral densities

PLTRMS Performs sensitivity plots of the gravimetric RMS errors against the tabulated values of the independent variable. The plotted curve is spline interpolated.

PLTSUR Performs the 3-D perspective plot of the residual undulation error spectral density on a two-dimensional domain of east and north frequencies

PROMPT Issues a prompt to the interactive user, and decodes the user's reply

SENSPLOT Supervises the production of sensitivity plots in a sensitivity run

3.4.9 Utility Routines

APPEND Appends one character string to the end of the last nonblank character of another (CHARACTER FUNCTION)

COMPARE Compares one character string with a reference string; returns a value of TRUE if the

input string matches or is a truncation of the reference string. The comparison is made in uppercase. (LOGICAL FUNCTION)

FFTMR	Computes a multivariate discrete Fourier transform using a double precision mixed-radix Fast Fourier Transform algorithm
MTEQUAT	Sets one double precision matrix equal to another
MTMFG	Inverts a square double precision matrix in place, using the standard Gauss-Jordan method; it also returns the matrix determinant
MTMULT	Computes the product of two double precision matrices
MTPRINT	Prints the contents of a real double precision matrix, with a title
MTSMLTC	Multiplies in place a complex double precision matrix by a real double-precision scalar
MTZERO	Sets a double precision matrix to zero
SIZE	Returns the length of the character-string argument after trailing blanks have been truncated (INTEGER FUNCTION)

3.5 UPPER-LEVEL INITIALIZATION ROUTINE DESCRIPTIONS

3.5.1 Subroutine CHKCONTR

CALLING SEQUENCE: CHKCONTR(NMLIST,LENGTH,COUNT,VALUE,ERROR)

FUNCTION: To check the run option variables for acceptable and consistent values, and issue diagnostics when errors are detected

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
NMLIST	CHAR	(*)	Input	List of variable names from namelist input
LENGTH	I*4	-	Input	Length of NMLIST vector
COUNT	I*4	-	Output	Number of variable values entered for sensitivity run
VALUE	R*8	(20)	Output	Vector of variable values entered for sensitivity run
ERROR	I*4	-	Output	Number of errors encountered

COMMON BLOCKS: CHARCONTR, INPUTS, CONTROL, TRANSFER

SUBPROGRAMS CALLED: LIB\$DATETIME, CHKGRAV

3.5.2 Subroutine CHKGRAV

CALLING SEQUENCE: CHKGRAV(ERROR)

FUNCTION: To check the gravity run descriptors for internal consistency, and issue diagnostics if errors are encountered

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
ERROR	I*4	-	Input	Cumulative error count before calling CHKGRAV
ERROR	I*4	-	Output	Cumulative error count after calling CHKGRAV

COMMON BLOCKS: CHARCONTR, INPUTS, CONTROL, TRANSFER, CONSTANTS

SUBPROGRAMS CALLED: GRADDEF

3.5.3 Subroutine CHKSENS

CALLING SEQUENCE: CHKSENS (VALUE,COUNT,IERR)

FUNCTION: To check the list of variable values for duplicates and validity, and issue diagnostics when an error is detected

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VALUE	R*8	(20)	Input	The list of variable values for a sensitivity run
COUNT	I*4	-	Input	The number of values in the list
IERR	I*4	-	Input	Cumulative error count before calling CHKSENS
IERR	I*4	-	Output	Cumulative error count after calling CHKSENS

COMMON BLOCKS: CHARCONTR,CONTROL

SUBPROGRAMS CALLED: *NONE*

3.5.4 Subroutine CHKVALUE

CALLING SEQUENCE: CHKVALUE(IERR)

FUNCTION: To check the values of general run parameters to ensure that they lie within valid ranges. Out-of-range values are flagged as input errors.

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
IERR	I*4	-	Input	Cumulative error count before calling CHKVALUE

ARGUMENTS: *NONE*

COMMON BLOCKS: WORK,TRANSFER,CONTROL,CHARCONTR

SUBPROGRAMS CALLED: GETTRAJ,FLTREF,TRANSMX,LAUNCH,GENSINE,
FLTPROP

3.6.2 Subroutine FLTPROP

CALLING SEQUENCE: FLTPROP(RCOS,RSIN,TIME,TMXT,MISS,NTMX)

FUNCTION: To compute the inflight transfer function and write
it to a file

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
RCOS	R*8	(0:1440)	Input	Table of pregenerated cosines
RSIN	R*8	(0:1440)	Input	Table of pregenerated sines
TMXT	R*8	(2,2,3,3,0)	Input	Array of transition matrices from launch to times in the trajectory
MISS	R*8	(2,6)	Input	Miss-partial matrix
NTMX	I*4	-	Input	Number of times on trajectory file
TIME	R*8	(0:1000)	Output	Array of times corresponding to inflight transfer function file records

COMMON BLOCKS: TRANSFER,CONTROL,CHARCONTR

SUBPROGRAMS CALLED: GANG

3.6.3 Subroutine FLTREF

CALLING SEQUENCE: FLTREF(TIME)

FUNCTION: To reformat a trajectory file from inertial Cartesian coordinates into flat-earth launch point coordinates

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
TIME	R*8	(0:1000)	Output	List of times for output trajectory file records

COMMON BLOCKS: TRANSFER, CONTROL, CHARCONTR

SUBPROGRAMS CALLED: GETTRAJ, ROTMAT, LIB\$DATETIME

3.6.4 Subroutine GETTRAJ

CALLING SEQUENCE: GETTRAJ(ITRAJ, TRAJFILE, FLAG, TIME, POS, VEL)

FUNCTION: To open, read, and close the input trajectory file when computing the inflight transfer function. May be replaced by a user whose file is in a nonstandard format.

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
ITRAJ	I*4	-	Input	FORTTRAN unit number of the trajectory file
TRAJFILE	CHAR	-	Input	File name of the trajectory file
FLAG	I*4	-	Input	Integer value set to indicate function to be performed: 0 = open trajectory file 1 = close trajectory file 2 = read next record and return contents in last two arguments

FLAG	I*4	-	Output	Integer value set to indicate result of the operation: 0 = performed with no errors 10 = end-of-file encountered
TIME	R*8	-	Output	Trajectory time read from record
POS	R*8	(3)	Output	Trajectory position read from record
VEL	R*8	(3)	Output	Trajectory velocity read from record

COMMON BLOCKS: *NONE*

SUBPROGRAMS CALLED: *NONE*

3.6.5 Subroutine LAUNCH

CALLING SEQUENCE: LAUNCH(TMXT,MISS,NTMX)

FUNCTION: To compute the miss-partial matrix from the launch point

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
TMXT	R*8	(2,2,3,3,0)	Input	Array of transition matrices from launch to times in the trajectory
NTMX	I*4	-	Input	Number of transition matrices (and index of the one from launch to impact)
MISS	R*8	(2,6)	Output	Miss-partial matrix in units of ft/meter and ft/(meter/sec)

COMMON BLOCKS: TRANSFER,CONTROL,CHARCONTR

SUBPROGRAMS CALLED: GETTRAJ,MTMULT,MTZERO,MTEQUAT,MTMFG

3.7 UPPER-LEVEL GRAVITY ROUTINE DESCRIPTIONS

3.7.1 Subroutine ALTIM

CALLING SEQUENCE: ALTIM(W1,W2,ALT1TERM,FINV)

FUNCTION: To evaluate the spectral density error contribution of the first satellite radar altimetry survey

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value
W2	R*8	-	Input	North frequency value
FINV	R*8	-	Input	Accumulator for inverse error contributions
ALT1TERM	R*8	-	Output	Error contribution from this call
FINV	R*8	-	Output	Updated accumulator for inverse error contributions

COMMON BLOCKS: INPUTS,CONSTANTS

SUBPROGRAMS CALLED: FFUNC,WFUNC

3.7.2 Subroutine ALTIM2

CALLING SEQUENCE: ALTIM2(W1,W2,ALT2TERM,FINV)

FUNCTION: To evaluate the spectral density error contribution of the second satellite radar altimetry survey

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value

W2	R*8	-	Input	North frequency value
FINV	R*8	-	Input	Accumulator for inverse error contributions
ALT2TERM	R*8	-	Output	Error contribution from this call
FINV	R*8	-	Output	Updated accumulator for inverse error contributions

COMMON BLOCKS: INPUTS, CONSTANTS

SUBPROGRAMS CALLED: FFUNC, WFUNC

3.7.3 Subroutine COMPGRAV

CALLING SEQUENCE: COMPGRAV(COVAR, DXRMS)

FUNCTION: To supervise the computation of the statistics of gravity residuals and impact errors for a single set of survey descriptions. Called repeatedly for different values of the independent variable in a sensitivity run.

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
COVAR	R*8	(*,*)	Output	The computed covariance of the requested gravity residuals
DXRMS	R*8	(3)	Output	The computed impact covariance as a three-vector, in the sequence: down-range variance, crossrange variance, and cross covariance

COMMON BLOCKS: WORK, CONTROL, MATSIZE, CHARCONTR, CONSTANTS, INPUTS, DATABLK

SUBPROGRAMS CALLED: GRAVCON, MATDIM, PRINTINI, GENSPEC, FOURIER, INFLIGHT, CEPCOMP, PRTCov, PRTPSD, MTPRINT, MTCORRC, PLTGRAV

3.7.4 Subroutine FOURIER

CALLING SEQUENCE: FOURIER(PHISUM,CBUF,RAC,COVAR)

FUNCTION: To compute the auto- and cross-covariance functions of the requested gravity residuals from their along-track power spectrum

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
PHISUM	C*16	(*,*,0:*)	Input	Alongtrack power spectrum of gravity quantities
CBUF	C*16	(*)	Output	Work area for Fourier transforms
RAC	R*8	(*,*:*)	Output	Auto- and cross covariance array as function of along track displacement
COVAR	C*16	(10,10)	Output	Zero-shift gravity error covariance

COMMON BLOCKS: INPUTS,CONSTANTS,CONTROL,MATSIZE

SUBPROGRAMS CALLED: FFTMR,MTPRINT

3.7.5 Subroutine GENSPEC

CALLING SEQUENCE: GENSPEC(PHISUM,PHI,TF1,TF2,OUTSPEC)

FUNCTION: To compute the residual gravity errors as a function of alongtrack and crosstrack frequency values, and integrate them across track

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
PHISUM	C*16	(*,*,0:*)	Output	The integrated residual gravity power spectrum

PHI	C*16	(*,*)	Output	Work area used for the residual covariance at each point
TF1	R*8	(0:*)	Output	Work area used to hold factors in area-mean computation
TF2	R*8	(0:*)	Output	Work area used to hold factors for area-mean computation
OUTSPEC	R*4	(*)	Output	Work-area used as buffer for generating the gravity error file for use in the impact calculation

COMMON BLOCKS: INPUTS,CONSTANTS,CONTROL,CHARCONTR,MATSIZE

SUBPROGRAMS CALLED: SPECTRM,MTSMLTC,MVECTOR

3.7.6 Subroutine GRADMTR

CALLING SEQUENCE: GRADMTR(W1,W2,GRADTERM,FINV,ZSWITCH)

FUNCTION: To evaluate the spectral density error contribution of the gradiometer survey at a given east and north frequency value

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value
W2	R*8	-	Input	North frequency value
FINV	R*8	-	Input	Cumulative inverse error before calling GRADMTR
GRADTERM	R*8	-	Output	Error contribution from this call
FINV	R*8	-	Output	Cumulative inverse error after call to GRADMTR

ZSWITCH	L*4	-	Output	Logical switch set if error contribution is zero (i.e. inverse contribution is infinite)
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COMMON BLOCKS: CONTROL,INPUTS,CONSTANTS

SUBPROGRAMS CALLED: NOISE,TVECTOR,SCALP,SQNORM

3.7.7 Subroutine GRAVCON

CALLING SEQUENCE: GRAVCON

FUNCTION: To compute constants used in the GRAVITY phase modeling

ARGUMENTS: *NONE*

COMMON BLOCKS: INPUTS,CONSTANTS,CONTROL,CHARCONTR

SUBPROGRAMS CALLED: GENDATA

3.7.8 Subroutine GRAVMTR

CALLING SEQUENCE: GRAVMTR(W1,W2,WSUM,GRAVTERM,FINV)

FUNCTION: To compute the spectral density error contribution of the gravimeter survey

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value
W2	R*8	-	Input	North frequency
WSUM	R*8	-	Input	Frequency magnitude
FINV	R*8	-	Input	Cumulative inverse error before call to GRAVMTR
GRAVTERM	R*8	-	Output	Spectral density error contribution from this call

FINV	R*8	-	Output	Cumulative inverse error after call to GRAVMTR
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COMMON BLOCKS: INPUTS,CONSTANTS,CONTROL

SUBPROGRAMS CALLED: FFUNC,GFUNC,HFUNC,TFGRAV

3.7.9 Subroutine MVECTOR

CALLING SEQUENCE: MVECTOR(MMSTAR,W1,W2,WSQ)

FUNCTION: To compute the outer product of the transfer function from the undulation spectral density to those of other selected gravimetric quantities

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value (radians/meter)
W2	R*8	-	Input	North frequency value (radians/meter)
WSQ	R*8	-	Input	Square magnitude frequency (= W1**2 + W2**2)
MMSTAR	C*16	(10,10)	Output	Transfer function matrix

COMMON BLOCKS: CONTROL,INPUTS

SUBPROGRAMS CALLED: *NONE*

3.7.10 Subroutine SPECTRM

CALLING SEQUENCE: SPECTRM(W1,W2,F,PHI,COMPPHI)

FUNCTION: To compute the spectral density of the residual undulation error at given east and north frequency values. If a switch is set, also computes the corresponding cross-spectral density in the selected gravimetric quantities.

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value
W2	R*8	-	Input	North frequency value
COMPPHI	L*4	-	Input	Logical switch to control computation of cross-spectral density of errors in selected gravimetric quantities
F	R*8	-	Output	Residual undulation error spectral density
PHI	C*16	(*,*)	Output	Cross-spectral density of errors in selected gravimetric quantities (if computed)

COMMON BLOCKS: CONSTANTS, INPUTS, CONTROL, MATSIZE

SUBPROGRAMS CALLED: ALTIM, ALTIM2, GRAVMTR, GRADMTR, SSTDOP, FFUNC

3.7.11 Subroutine SSTDOP

CALLING SEQUENCE: SSTDOP(W1, W2, SSTTERM, FINV, ZSWITCH)

FUNCTION: To evaluate the spectral density error contribution of the satellite-to-satellite doppler survey

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
W1	R*8	-	Input	East frequency value
W2	R*8	-	Input	North frequency value
FINV	R*8	-	Input	Accumulator for inverse error contributions

SSTTERM	R*8	-	Output	Error contribution from this call
FINV	R*8	-	Output	Updated accumulator for inverse error contributions
ZSWITCH	L*4	-	Output	Switch set if contribution is zero (inverse contribution is infinite)

COMMON BLOCKS: CONSTANTS, INPUTS

SUBPROGRAMS CALLED: FFUNC, TFSST

3.8 UPPER-LEVEL IMPACT COMPUTATION ROUTINE DESCRIPTIONS

3.8.1 Subroutine CEPCOMP

CALLING SEQUENCE: CEPCOMP(DXCOV, DXCEP)

FUNCTION: To compute the downrange and crossrange impact standard deviations and circular error probable (CEP) from the impact covariance

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
DXCOV	R*8	(3)	Input	Impact covariance as a three-vector, in order: downrange variance, crossrange variance, cross-covariance
DXCEP	R*8	(3)	Output	Impact errors as a three-vector, in order: downrange sigma, crossrange sigma, CEP

COMMON BLOCKS: *NONE*

SUBPROGRAMS CALLED: *NONE*

3.8.2 Subroutine INFLIGHT

CALLING SEQUENCE: INFLIGHT(DXCOV)

FUNCTION: To compute the impact covariance matrix from the gravity errors and the inflight transfer function

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
DXCOV	R*8	(3)	Output	Impact covariance as a three-vector, in the sequence: downrange variance, crossrange variance, and cross covariance

COMMON BLOCKS: WORK,TRANSFER,CONTROL,CHARCONTR

SUBPROGRAMS CALLED: SETPOT,SETCOMP,SETSUM,INTX

4.

MULTIJOB PROGRAM DESCRIPTION

4.1 PROGRAM ORGANIZATION

MULTIJOB an interactive program consisting of a main routine and 33 subroutines. It also uses the following routines from various system application libraries:

- UTILLIB utility library
- System utility library.

Of the 34 subroutines used by MULTIJOB, four are also used by MULTIJOB and MULTISENS. These routines consist mainly of terminal input/output routines.

The calling structure of MULTIJOB is shown in Fig. 4.1-1. The main routine as well as all those routines having names beginning with ASK, prompt the user for major input information. The survey input parameters and all general numeric input parameters are checked in the routines beginning with CHK. Those routines starting with WRT are used to write the control input file.

Since the program allows the user to back up to a previous prompt, flow through this program goes in both directions. Alternate returns as part of subroutine argument lists are used to send control back to a prior section. When set backwards, only those parameters in the common block INPUTCHAR are reset to their original values. The other parameters retain their current values.

4.2 MAIN ROUTINE DESCRIPTION

This routine controls the major flow of the program. It determines from the user whether the input verification mode is to be used, and what phases are to be included in the MULTISENS run. If the TRANSFER and/or IMPACT phases are included, the routine will ask for more information directly. If the GRAVITY phase is included, more information will be obtained through the call to ASKGRAV.

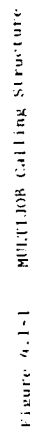
After all information needed for the MULTISENS run is gathered, the main routine issues a call to WRTFILE to generate the control input file. The main routine then asks whether the program is to be restarted, and if so, control returns to the beginning of the main routine.

SUBPROGRAMS CALLED: ANSWER, BLANK, CHGVAR, CHKFILE, CHKFILE,
CHKIMP, TASC_SCROLL, WRTFILE, PRTHelp,
RESPOND, PROMPT, ASKGRAV

COMMON BLOCKS: INPUTCHAR, CONTROL, INPUTVAR, INPUTFLG

4.3 BLOCK DATA DESCRIPTION

A named block data BLKDATA is used to initialize the character arrays that contain the names of the input variables, their units, and initial values. It also initializes the input flag arrays with zeros. The common blocks included in the block data are INPUTVAR and INPUTFLG. The common blocks and what they contain will be discussed in the next section.



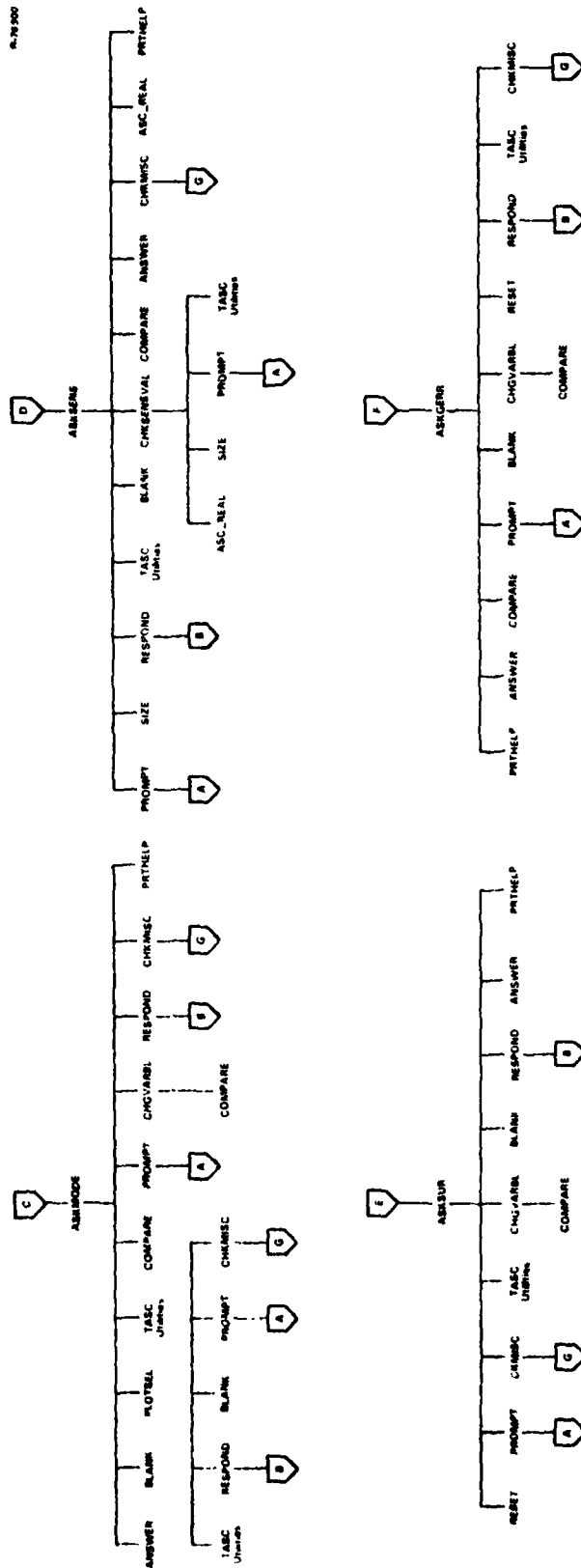


Figure 4.1-1 MULTIJOB Calling Structure (Cont.)

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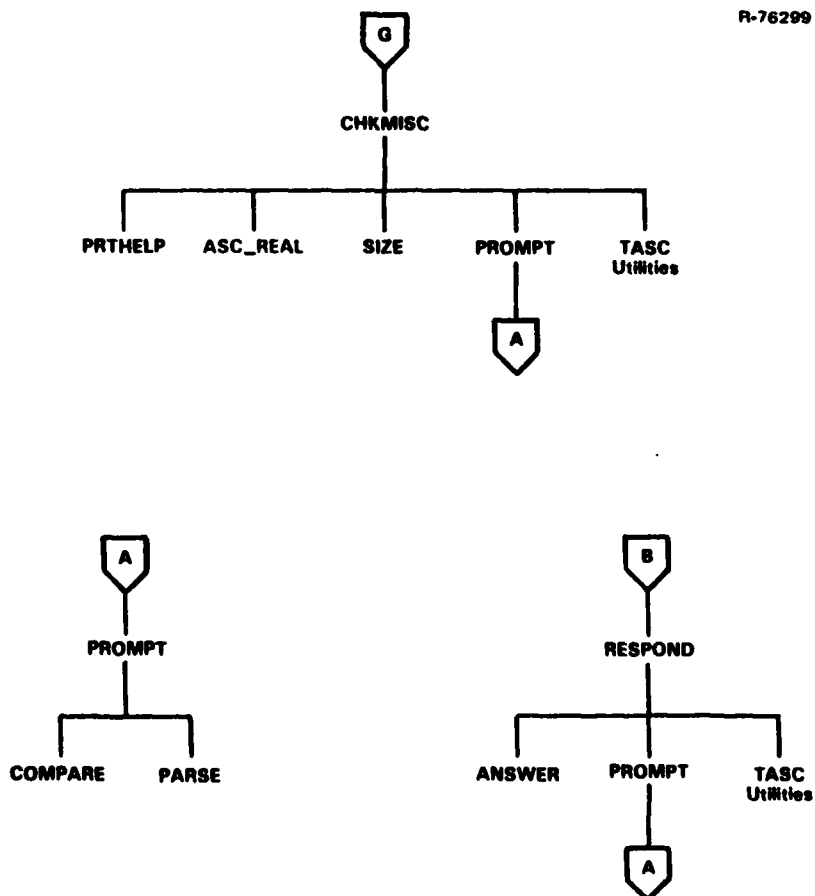


Figure 4.1-1 MULTIJOB Calling Structure (Cont.)

4.4 COMMON BLOCK DESCRIPTION

The MULTIJOB program uses five common blocks, all located in separated files and included where needed in the source with INCLUDE statements. The common blocks are:

CONTROL

This common block is the same as the one used in the MULTISENS program. It contains the variables which control the flow of MULTISENS and the switches for the various options. They are arranged as follows:

NAME	TYPE	DIM	DESCRIPTION
INDXOUT	INTEGER*4	10	Indices of gravimetric quantities to be included
JPRINT	INTEGER*4	-	Debug print level for GRAVITY phase
M1	INTEGER*4	-	Number of alongtrack frequency intervals
M1PLOT	INTEGER*4	-	Number of alongtrack grid points in 3-D or contour plot
M2	INTEGER*4	-	Number of crosstrack frequency intervals
M2PLOT	INTEGER*4	-	Number of crosstrack grid points in 3-D or contour plot
NFIELD	INTEGER*4	-	Number of gravimetric quantities to be included
IFLTER	INTEGER*4	-	FORTTRAN unit number for flat-earth temporary file used in TRANSFER phase
IGRAV	INTEGER*4	-	FORTTRAN unit number for GRAVFILE

IPLOT	INTEGER*4	-	FORTTRAN unit number for PLOTFILE
IPRINT	INTEGER*4	-	FORTTRAN unit number for printout
IREAD	INTEGER*4	-	FORTTRAN unit number for control input
ITRAJ	INTEGER*4	-	FORTTRAN unit number for TRAJFILE
IUSER	INTEGER*4	-	FORTTRAN unit number for USERFILE files
IUSFILE	INTEGER*4	-	Number of USERFILES specified
IXFER	INTEGER*4	-	FORTTRAN unit number for TRANSFILE
ALTSW	LOGICAL*4	-	ALT1 altimeter survey switch
ALTSWP	LOGICAL*4	-	ALT2 altimeter survey switch
DEBUG	LOGICAL*4	-	Debug printout switch for TRANSFER phase
EOTVOSW	LOGICAL*4	-	Eotvos error switch for gravimeter survey
GRADROT	LOGICAL*4	-	Switch for umbrella gradiometer geometry
GRAVSW	LOGICAL*4	-	Gravimeter survey switch
MEANSW	LOGICAL*4	-	Switch for area-mean gravity statistics
SSTSW	LOGICAL*4	-	SST survey switch
SWGRAD	LOGICAL*4	3	Vector of switches for 3 components of gradiometer survey
USDSW	LOGICAL*4	-	Switch for applying scale factor to NUMERIC model input data

PLT3D	LOGICAL*4	-	Switch for 3-D plot
PLTCNT	LOGICAL*4	-	Switch for contour plot
PLTCOH	LOGICAL*4	-	Switch for coherency plots
PLTCOR	LOGICAL*4	-	Switch for correlation plots
PLTCOV	LOGICAL*4	-	Switch for covariance plots
PLTPSD	LOGICAL*4	-	Switch for power spectrum plots
PLTSENS	LOGICAL*4	-	Switch for sensitivity plots
GFILESAV	LOGICAL*4	-	Switch to retain GRAVFILE at end of run
GRAVITY	LOGICAL*4	-	Switch for GRAVITY phase
IMPACT	LOGICAL*4	-	Switch for IMPACT phase
KEEPFILE	LOGICAL*4	-	Switch to generate GRAVFILE file
PLOTSAV	LOGICAL*4	-	Switch to generate PLOTFILE file
TRANSFER	LOGICAL*4	-	Switch for TRANSFER phase
XFILESAV	LOGICAL*4	-	Switch to retain TRANSFILE at end of run

INPUTCHAR

This common block contains the variables which are character inputs to the MULTISENS program and some character control variables for the MULTIPLOT program. The only variable which has a different declaration from its counterpart in MULTISENS is VALUE, which in MULTIJOB is a character array containing the character numbers. They are arranged as follows:

NAME	TYPE	DIM	DESCRIPTION
TYPE_OF_RUN	CHAR*10	(3)	Program phase selection
TRAJFILE	CHAR*80	-	Trajectory filename
TRANSFILE	CHAR*80	-	Filename for in flight transfer function file
MODEL	CHAR*10	-	Gravity model descriptor
USERFILE	CHAR*80	(3)	Filenames for NUMERIC model undulation files
GRAVERR	CHAR*10	(10)	List of gravimetric quantities
SURVEY	CHAR*10	(5)	Survey model descriptors
GRADSEL	CHAR*2	-	Gradiometer selection flag
SENSITIVITY	CHAR*10	-	Sensitivity run type indicator
MODE	CHAR*10	-	GRAVITY phase output descriptor
VARIABLE	CHAR*10	-	Sensitivity independent variable
VALUE	CHAR*20	(20)	Sensitivity variable values
PLOT	CHAR*10	(8)	Plot option descriptor
PLOTFILE	CHAR*80	-	Filename for output plot file
SWGRADCH	CHAR*10	(3)	Gradiometer axis selection descriptor
WHTNSE	CHAR*20	(6)	Gradiometer white noise values
RDNSE	CHAR*20	(6)	Gradiometer red noise values
GRAVFILE	CHAR*80	-	Filename for undulation PSD file

INPUTFL

This common block contains the integer arrays which function as change flags for the input parameters. They are arranged as follows:

NAME	TYPE	DIM	DESCRIPTION
GEOSFLAG	I*4	(7)	ALT1 survey parameter change flag
GRADFLAG	I*4	(7)	Gradiometer survey parameter change flag
GRAVFLAG	I*4	(6)	Gravimeter survey parameter change flag
SEAFLAG	I*4	(7)	ALT2 survey parameter change flag
SSTFLAG	I*4	(7)	SST survey parameter change flag
TRANFLAG	I*4	(5)	Inflight transfer function parameter change flag
IMPFLAG	I*4	(1)	IMPACT phase parameter change flag
MISCFLAG	I*4	(17)	General input parameter change flag

INPUTVAR

This common block contains the character arrays which hold the numeric input for MULTISENS. Also included are the parameter names and their units. The variables in this common block, their declarations, dimensions, and a brief description are as follows:

NAME	TYPE	DIM	DESCRIPTION
GEOSVAR	CHAR*20	(7)	ALT1 input variable names

GEOSVAL	CHAR*20	(7)	ALT1 input variable values
GEOSUNIT	CHAR*15	(7)	ALT1 input variable units
GRADVAR	CHAR*20	(7)	Gradiometer input variable names
GRADVAL	CHAR*20	(7)	Gradiometer input variable values
GRADUNIT	CHAR*15	(7)	Gradiometer input variable units
GRAVVAR	CHAR*20	(6)	Gravimeter input variable names
GRAVVAL	CHAR*20	(6)	Gravimeter input variable values
GRAVUNIT	CHAR*15	(6)	Gravimeter input variable units
SEAVAR	CHAR*20	(7)	ALT2 input variable names
SEAVAL	CHAR*20	(7)	ALT2 input variable values
SEAUNIT	CHAR*15	(7)	ALT2 input variable units
SSTVAR	CHAR*20	(7)	SST input variable names
SSTVAL	CHAR*20	(7)	SST input variable values
SSTUNIT	CHAR*15	(7)	SST input variable units
TRANVAR	CHAR*20	(5)	Inflight transfer function phase input variable names
TRANVAL	CHAR*20	(5)	Inflight transfer function phase input variable values
TRANUNIT	CHAR*15	(5)	Inflight transfer function phase input variable units
IMPVAR	CHAR*20	(1)	IMPACT phase input variable name
IMPVAL	CHAR*20	(1)	IMPACT phase input variable value
IMPUNIT	CHAR*15	(1)	IMPACT phase input variable unit

MISCVAR	CHAR*20	(17) General input parameters variable names
MISCVAL	CHAR*20	(17) General input parameters variable values
MISCUNIT	CHAR*15	(17) General input parameters variable units

4.5 SUBROUTINE NAMES AND DESCRIPTIONS

The subroutines for this program have been grouped in six different categories.

- Upper-Level - These subroutines prompt for most of the data necessary to create the control input file. There is one routine for each major section of input for MULTISENS.
- Lower-Level - These subroutines are of less importance and may not be called in the MULTIJOB run depending on the options requested.
- Value Verification - These subroutines check input values for consistency, non-numeric values, and out of range values.
- Input Processing - These subroutines take the input string and operate on it to put it in a form for the program to use.
- File Output - These subroutines do the writing of the control input file.
- Utility - These subroutines perform general utility functions.

Some of the subroutines used in this program are also used in the other Multisensor Simulation Software. A list of the subroutines in each category follows.

Also used are two routines from system libraries.
These routines are:

- TASC SCROLL is used for the selective scrolling of the VT100.
- LIB\$ERASE_PAGE is used for the selective clearing of the VT100 screen.

4.5.1 Upper-Level Routines

ASKGERR	Prompts the user for information on the gravimetric quantities. Also checks the inputs for validity and duplicate values.
ASKGRAD	Prompts the user for the gradiometer red and white noise parameters if the survey GRAD was selected
ASKGRAV	Main controller routine for the gravity phase. Also prompts and checks for the survey parameters of selected surveys.
ASKMODE	Prompts for information regarding the MODE of the MULTISENS run. Also asks whether plotting is to be done when the appropriate mode is selected.
ASKMODEL	Prompts the user for the gravity model to be used in the MULTISENS run. Also asks for additional information depending on the model selected.
ASKSENS	Prompts for the sensitivity information. Also checks for a valid sensitivity variable depending on the surveys selected.
ASKSUR	Prompts for the type of surveys to be included in the MULTISENS job. Also checks the inputs for validity and duplication, and prompts for more information if the surveys selected require it.

4.5.2 Lower-Level Routines

- PLOTSEL Prompts the user for which plots are desired, taking into account what mode has been selected. The input is checked for validity and duplicate values. Also asks for more information if CONTOUR or 3-D has been selected.
- PRTHELP Called when the user has entered HELP. Prints out a message to help the user in the present location.
- RESET Blanks out input characters when the program is reset to a previous location. It is done by overlaying a character array on the INPUTCHAR common.

4.5.3 Value Verification Routines

- CHKALT Checks the altimeter survey parameters for non numeric and out-of-range values. Checks only those variables whose values have been changed. If an error is detected, the user is prompted to reenter the value.
- CHKFILE Checks a filename for a valid file specification and/or for existence of the file.
- CHKGRAD Checks the gradiometer survey parameters for nonnumeric and out-of-range values. Checks only those variables whose values have been changed. If an error is detected, the user is prompted to reenter the value.
- CHKGRVMTR Checks the gravimeter survey parameters for nonnumeric and out-of-range values. Checks only those variables whose values have been changed. If an error is detected, the user is prompted to reenter the value.
- CHKIMP Checks the IMPACT phase parameter for non-numeric and out-of-range value. Checks the variable only if its value has been changed. If an error is detected, the user is prompted to reenter the value.

- CHKMISC** Checks the general miscellaneous parameters for nonnumeric and out-of-range values. Checks only those variables whose values have been changed. If an error is detected, the user is prompted to reenter the value.
- CHKSENV** Checks the values entered for the sensitivity variable for nonnumeric and out-of-range values. If an error is detected the user is prompted to reenter the value. The routine also eliminates any duplication of values.
- CHKSST** Checks the SST survey parameters for non-numeric and out-of-range values. Checks only those variables whose values have been changed. If an error is detected, the user is prompted to reenter the value.
- CHKTRAN** Checks the inflight transfer function phase parameters for nonnumeric and out-of-range values. Checks only those variables whose values have been changed. If an error is detected, the user is prompted to reenter the value.

4.5.4 Input Processing Routines

- CHGVAR** Presents a list of input parameters in a table format. The user can enter a new value or maintain the old. Will also accept the special words QUIT, BACK, and HELP, and return control to the calling program by alternate returns.
- PARSE** Parses a character string to the next delimiter symbol (' '(blank), ',', ';', '/', '(', ')', '|', and '>')
- PROMPT** Prompts the user with a given character string and accepts a line of input. The input line is then parsed into words returned to the calling routine. The special words QUIT, BACK, and HELP are trapped by the routine and control is returned to the calling routine via alternate returns.

RESPOND Echoes what the user has entered and prompts the user for any changes. It is used in the input verification mode of MULTIJOB. The special words QUIT, BACK, and HELP are trapped by the routine and control is returned to the calling routine via alternate returns.

4.5.5 File Output Routines

WRTFILE Main controller routine for creating the control input file. Asks whether the file is to be submitted and/or saved. Also allows the user to restart the program via an alternate return.

WRTFLNM Writes a filename to the control input file making sure that the line being written is not greater than 80 characters.

WRTVCTR Writes a list to the output file in the correct format for the namelist input. If the current line is greater than 80 characters, the list is split into two or more lines.

4.5.6 Utility Routines

ANSWER Returns .TRUE. if the character string given contains either a 'Y', 'YE', or 'YES' and YES is placed in the character string. A .FALSE. is returned if the character string contains 'N', 'NO', or 'BACK'. Anything other input reprompts the user again. (LOGICAL FUNCTION)

ASC_INT Returns the integer value translated from a character string. If the character string does not contain a valid integer number, an error flag is set. (FUNCTION)

ASC_LOG Returns the logical value translated from a character string. If the character string does not contain a valid logical value an error flag is set. (FUNCTION)

ASC_REAL Returns the real value translated from a character string. If the character string does not contain a valid real number, an error flag is set. (FUNCTION)

BLANK Produces a number of blank lines on the screen depending on the input parameter.

COMPARE Returns .TRUE. if the two character argument are equal or if the second is at least a three character substring of the first argument beginning with the first letter. (FUNCTION)

SIZE Returns the length to the last nonblank character of a character string. (FUNCTION)

4.6 UPPER-LEVEL ROUTINES

The upper-level routines as listed above are presented in more detail in this section.

4.6.1 Subroutine ASKGERR

CALLING SEQUENCE: ASKGERR(VERIFY,*)

FUNCTION: To prompt the user for information on the gravimetric quantities, and check the inputs for validity and duplicate values

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verification mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user

wants to return to
a previous prompt

COMMON BLOCKS: INPUTCHAR,CONTROL,INPUTVAR,INPUTFLG

SUBPROGRAMS CALLED: COMPARE, ANSWER, RESET, PROMPT, BLANK,
RESPOND, CHGVARBL, CHKMISC, PRTHelp,
TASC_SCROLL

4.6.2 Subroutine ASKGRAD

CALLING SEQUENCE: ASKGRAD(VERIFY,*)

FUNCTION: To prompt the user for the gradiometer red and white
noise parameters if the survey GRAD was selected

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verifica- tion mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user wants to return to a previous prompt

COMMON BLOCKS: INPUTCHAR,CONTROL,INPUTVAR,INPUTFLG

SUBPROGRAMS CALLED: ASC_REAL,PROMPT,BLANK,RESPOND,PRTHelp,
TASC_SCROLL

4.6.3 Subroutine ASKGRAV

CALLING SEQUENCE: ASKGRAV(VERIFY,*)

FUNCTION: Main controller routine for the GRAVITY phase.
Prompts and checks for the survey parameters of
selected surveys.

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verification mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user wants to return to a previous prompt

COMMON BLOCKS: INPUTCHAR, CONTROL, INPUTVAR, INPUTFLG

SUBPROGRAMS CALLED: ANSWER, TASC SCROLL, ASKMODEL, ASKGERR, ASKSUR, RESET, PROMPT, ASKSENS, ASKMODE, CHGVARBL, BLANK, CHKALT, CHKGRVMTR, CHKFILE, PRTHelp

4.6.4 Subroutine ASKMODE

CALLING SEQUENCE: ASKMODE(VERIFY,*)

FUNCTION: To prompt for information regarding the MODE of the MULTISENS run, and to determine whether plotting is to be done when the appropriate mode is selected

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verification mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user wants to return to a previous prompt

COMMON BLOCKS: INPUTCHAR,CONTROL,INPUTVAR,INPUTFLG

SUBPROGRAMS CALLED: ANSWER,COMPARE,PROMPT,BLANK,RESPOND,
CHKMISC,CHKFILE,PLOTSEL,CHGVARBL,PRTHELP,
TASC_SCROLL

4.6.5 Subroutine ASKMODEL

CALLING SEQUENCE: ASKMODEL(VERIFY,*)

FUNCTION: To prompt the user for the gravity model to be used
in the MULTISENS run, and to ask for additional
information depending on the model selected

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verifica- tion mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user wants to return to a previous prompt

COMMON BLOCKS: INPUTCHAR,CONTROL,INPUTVAR,INPUTFLG

SUBPROGRAMS CALLED: COMPARE, RESET, PROMPT, RESPOND, CHKFILE,
BLANK, CHKMISC, PRTHELP, TASC_SCROLL

4.6.6 Subroutine ASKSENS

CALLING SEQUENCE: ASKSENS(VERIFY,*)

FUNCTION: To prompt for the sensitivity information, and check
for a valid sensitivity variable depending on the
surveys selected

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verification mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user wants to return to a previous prompt

COMMON BLOCKS: INPUTCHAR,CONTROL,INPUTVAR,INPUTFLG

SUBPROGRAMS CALLED: ANSWER, ASC REAL, COMPARE, TASC_SCROLL, PROMPT, CHKMISC, BLANK, RESPOND, CHKSENVAL, CHKFILE, PRTHelp, SIZE

4.6.7 Subroutine ASKSUR

CALLING SEQUENCE: ASKSUR(VERIFY,*)

FUNCTION: To prompt for the type of survey to be included in the MULTISENS job, check the inputs for validity and duplication, and prompt for more information if the surveys selected require it

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
VERIFY	L*4	-	Input	A logical value signifying whether the input verification mode is on (.TRUE.) or off (.FALSE.)
*	AltRet	-	Output	An alternate return specifying where to go in the calling routine if the user wants to return to a previous prompt

COMMON BLOCKS: INPUTCHAR, INPUTVAR, INPUTFLG, CONTROL

SUBPROGRAMS CALLED: ANSWER, RESET, PROMPT, RESPOND, CHGVARBL,
BLANK, CHKMISC, PRTHelp, TASC_SCROLL

5.

MULTILOT PROGRAM DESCRIPTION

5.1 PROGRAM ORGANIZATION

MULTILOT is an interactive program consisting of 21 subroutines in addition to a main routine. It also makes use of routines in the following libraries:

- The TASC Software Graphics Package
- The IMSL mathematical library
- The screen formatting routines from TASCLIB
- The screen manipulation routines from the system library.

Since this program is basically the plotting routines from MULTISENS, gathered under a new main routine and slightly altered driver routines, 19 of the 21 subroutines used by MULTILOT are also used by MULTISENS. In addition, four subroutines are also used by MULTIJOB. Table 3.1-1 contains a list of all subroutines shared among the three programs. Also the common blocks used in this program are a subset of the common blocks used in MULTISENS.

The calling structure of MULTIJOB is shown in Fig. 5.1-1. Depending on information obtained from an input file, either the routine PLOTSSENS or the routine PLOTGRAV will be called. These are the main driver routines for the plotting options. These in turn will call the routines whose names begin with PLT to do the individual types of plots. These routines in their turn call upon the plotting package

routines. The individual plotting package routines are not shown in the figure but are included under the blocks labeled Plotting Package.

5.2 MAIN ROUTINE DESCRIPTION

This routine prompts the user for a file created by MULTISENS and from that file determines whether sensitivity or gravimetric statistic plots are to be drawn. Depending on which plots are available, either PLOTSSENS or PLOTGRAV is called. Control is returned to this routine if the user wishes to read another file.

The information stored in the file is read into arrays which are overlayed on the common blocks INPUT, CONSTANT, CONTROL, CHARCONTR, and MATSIZE.

This routine also contains a number of error traps to signal input file errors. If an error is detected, a message is printed, and control returns to the enter filename prompt.

SUBPROGRAMS CALLED: COMPARE,PLOTGRAV,PLOTSSENS

COMMON BLOCKS: MATSIZE,INPUT,CONTROL,CONSTANT,CHARCONTR

5.3 COMMON BLOCK DESCRIPTION

There are 11 common blocks used by this program and also used in the MULTISENS program. These common blocks are

- CHARCONTR
- CONTROL

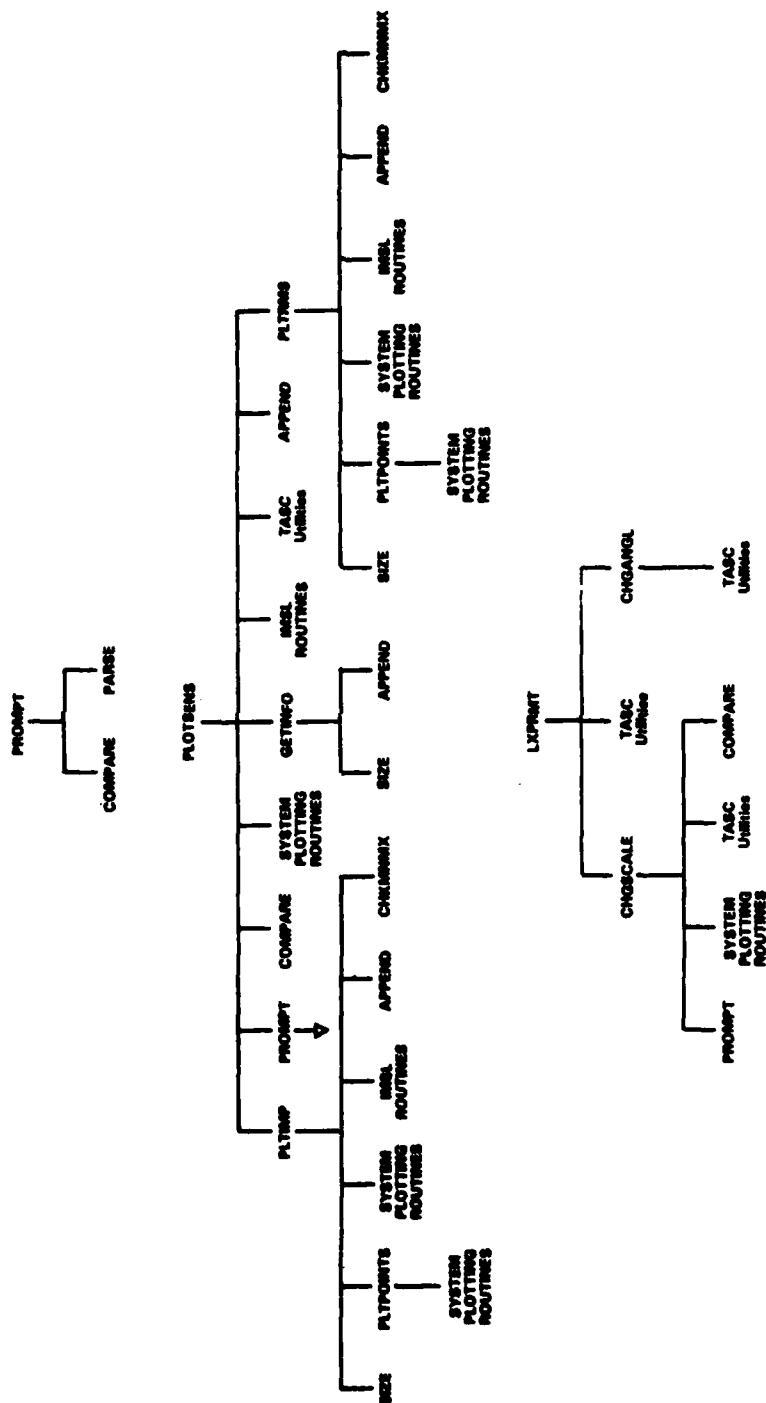


Figure 5.1-1 MULTIPLY Calling Structure

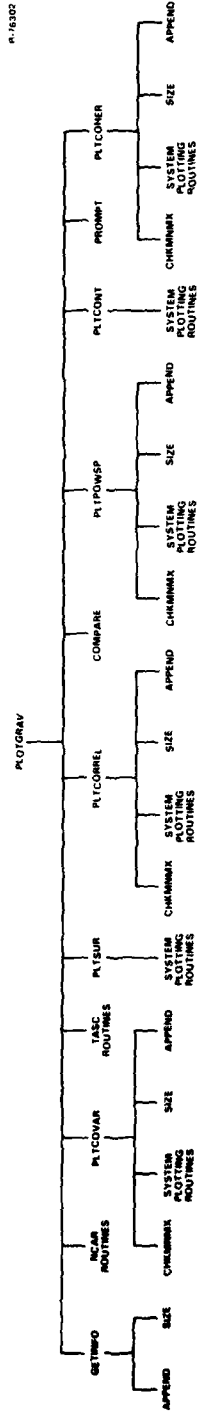


Figure 5.1-1 MOLDPLD Calling Structure (Cont.)

- CONSTANT
- CRLABS
- CRMNMX
- CRTICS
- INPUT
- LEXINFO
- MATSIZE
- SRLABSC
- SRMNMX.

The common blocks are discussed in more detail in section 3.3. Of the 11 common blocks, six are used to communicate with the plotting package.

5.4 SUBROUTINE NAMES AND DESCRIPTIONS

The subroutines used in this program can be grouped into four categories. These are:

- Upper-level - These are the main drivers and controller routines for the two major groups of plots that the program can produce. These routines prompt the user for the type of plot and call the appropriate routines to do the plotting.
- Plotting - These routines take the appropriate matrices and call the system plotting package to draw the plots. Each routine draws one type of plot.
- Plot Utilities - These routines display the plot menu and provide general help for the plotting routines.

- Utilities - These routines are general routines to format output and decode input.

Most of the subroutines used in this program are also used in the MULTISENS program. The only ones not used are the upper-level routines PLOTSSENS and PLOTGRAV. These are modifications of the routines SENSPLIT and PLTGRAV used in MULTISENS.

Some of the subroutines are from system libraries:

Plotting Library AGSETI, AGSETF, ANOTAT, DISPLA, EZCNTR, EZSRFC, EZXY, FRAME, GETSET, POINTS, PWRT

IMSL Library UGETIO, VSRTR, ICSICU, ICSEVU

Utility Library TASC_BATCH, TASC_SCROLL

System Library LIB\$ERASE_PAGE

Below is a list of all other subroutines called by MULTILOT grouped according to the categories listed above.

5.4.1 Upper-Level Routines

PLOTSSENS Called only if sensitivity plots are to be drawn. Reads in the matrices from the input file and then prompts the user for which plot is desired and calls the appropriate routines.

PLOTGRAV Called only if the gravimetric statistical plots are to be drawn. Reads in the matrices from the input file and then prompts the user for which type of plot is desired and calls the appropriate routines.

5.4.2 Plotting Routines

PLTCOHER Plots the coherence

PLTCONT Draws contour plot

PLTCORREL Draws correlation plots
 PLTCOVAR Draws covariance and cross covariance plots
 PLTIMP Draws impact sensitivity plots
 PLTPOWSP Draws power spectral densities and cross densities
 PLTRMS Draws either the AREAMEAN or RMS sensitivity plots depending on the array supplied
 PLTSUR Draws the three-dimensional surface plot

5.4.3 Plot Utility Routines

CHGANGL Prompts the user for information to change the viewing angle of the surface plot
 CHGSCALE Called when the user wishes to change the scale on any plot except for the contour or surface plots. The user is prompted for information to change the scale.
 LXPRMT Revised routine from the plotting package. Displays the plot menu and checks if the program running is a batch or terminal job. A batch job is toggled between printing a hard copy and going to the next plot.
 PLTPOINTS Places a character on the plot so that the character is centered over the plotted point

5.4.4 Utility Routines

APPEND Appends one character string after the last nonblank character of another character string (CHARACTER FUNCTION)
 CHKMMX Checks whether an axis of a plot spans or contains a zero
 GETINFO Supplies the information that appears below a plot and at the top of the VT100 screen

COMPARE Returns .TRUE. if the two character strings are equal or if the second is at least a three character substring of the first argument beginning with the first letter. (LOGICAL FUNCTION)

PARSE Parses a character string to the next delimiter symbol (' '(blank), ',', ';', '/', '(', ')', '|', and '>')

PROMPT Prompts the user with a given character string and accepts a line of input. The input line is then parsed into words returned to the calling routine. The special words QUIT, BACK, and HELP are trapped by the routine and control is returned to the calling routine via alternate returns.

SIZE Returns the length to the last nonblank character of a character string (FUNCTION)

5.5 UPPER-LEVEL ROUTINE DESCRIPTIONS

5.5.1 Subroutine PLOTGRAV

CALLING SEQUENCE: PLOTGRAV(PHISUM,PLOTSPC,RAC)

FUNCTION: Controller for the statistical plots. Prompts the user to enter the type of plot and directs control to plot it.

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
PHISUM	C*16	(*,*,0:*)	Input	An adjustable array which contains the power spectral density and the cross power spectral density
PLOTSPC	R*8	(*,*)	INPUT	An adjustable array which contains the information for the contour and surface plots

RAC	R*8	(*,*:*)	INPUT	An adjustable array which contains the covariance sequence
-----	-----	----------	-------	------------------------------------------------------------------

COMMON BLOCKS: MATSIZE,CHARCONTR

SUBPROGRAMS CALLED: AGSETI,AGSETF,LIB\$ERASE PAGE,GETINFO,
TASC_SCROLL,PROMPT,PLTCOVAR,PLTCORREL,
PLTPOWSP,PLTCOHER,PLTSUR,PLTCONT

5.5.2 Subroutine PLOTSENS

CALLING SEQUENCE: PLOTSENS(SENSCOVAR)

FUNCTION: Controller for the display of the sensitivity plots

ARGUMENTS:

NAME	TYPE	DIMENSION	IN/OUT	DESCRIPTION
SENSCOVAR	R*8	(*,*,20)	Input	An adjustable array which contains the series of covariance plots for the sensi- tivity run

COMMON BLOCKS: CHARCONTR,MATSIZE

SUBPROGRAMS CALLED: UGETIO, VSRTR, DISPLA, AGSETI, AGSETF,
LIB\$ERASE_PAGE, GETINFO, TASC_SCROLL,
PROMPT, PLTIMP, PLTRMS

SUMMARY

The multisensor simulation software consist of three programs: MULTIJOB, MULTISENS, and MULTIPLOT. Of the three, MULTISENS is the major program, with the other two acting as utility programs.

The MULTIJOB program is an interactive program used to guide a user in setting up the control input file for MULTISENS. The program will check the inputs for consistency and validity. It will guide the user through the many options available for MULTISENS.

The MULTISENS program will analyze a trajectory to compute the transfer function relating gravimetric errors to impact errors, simulate the user-specified multisensor surveys to compute the postsurvey residual gravimetric error statistics, and use the results of these two calculations to compute the statistics of impact errors induced by the residual gravity field. It can also be used to find the sensitivity of the computed error statistics to one of a subset of the input parameters. This program was designed to run as a batch job but can be run at the terminal.

MULTIPLOT is another interactive program used to display plots generated by a previous MULTISENS run. The user can view these plots and modify their appearance.

The multisensor simulation software is described in this report in the form of a user's guide and detailed software documentation for all three programs. The user's guide describes what inputs are needed to run the programs and what

the outputs are. The software documentation includes the program organization, main routine descriptions, descriptions of the common blocks used, and a list of all the subroutines used, with a more detailed description of the upper-level routines.

REFERENCES

1. Goldstein, J.D., "Analysis and Simulation of Multisensor Gravity Surveys and Associated Ballistic Missile Impact Errors (U)," The Analytic Sciences Corporation, Report No. TR-868-1-3, December 1980.
2. Gelb, A. (Ed.), Applied Optimal Estimation, MIT Press, Cambridge, 1974.
3. Heller, W.G., and Jordan, S.K., "Attenuated White Noise Statistical Gravity Model," Journal of Geophysical Research, Vol. 84, No. B9, August 1979.
4. White, J.V., "Error Models for Gravity Gradiometers in Airborne Surveys," The Analytic Sciences Corporation, Report No. TR-868-2, January 1980.

APPENDIX A
LIST OF MULTISENS INPUT PARAMETERS

NAME	TYPE	DIM	DEFAULT	DESCRIPTION
General run options				
TYPE_OF_RUN	Char	3	None	Phases of program to be executed
TRAJFILE	Char	-	None	Input trajectory filename
TRANSFILE	Char	-	Note 1	Inflight tranfer function filename
GRAVFILE	Char	-	Note 2	Geoid undulation density
USERFILE	Char	3	Note 3	Input filename(s) for NUMERIC model
TRANSFER phase parameters				
TDEPLOY	Real	-	400.	Deployment time in sec from launch
LAMBDAO	Real	-	2400.	Longest non-DC wavelength (nm)
CRIT	Real	-	1.E-2	Criterion for attenuation factor
NFM1	Integer	-	10	Control for number of table entries
NWAVE	Integer	-	12	Subdivisions of wavelength
DEBUG	Logical	-	.FALSE.	TRANSFER debug print switch
MDEBUG	Integer	-	0	TRANSFER debug print loop index
General GRAVITY phase parameters				
GRAVERR	Char	10	UND	List of gravimetric quantities
MODE	Char	-	RMS	Gravity statistics run option
TRKANGL	Real	-	0.	Track angle in deg from east
ALTITUDE	Real	-	0.	Altitude for gravimetric errors
EL	Real	-	0.	Mean latitude of estimation region
GRIDSAVE	Real	-	1.	Integration grid change factor
JPRINT	Integer	-	0	GRAVITY debug print level
GRAVITY integration region definition (For MODE=PSD or COV only)				
M1	Integer	-	100	Number of frequency increments alongtrack

M2	Integer	-	100	Number of frequency increments crosstrack
SAMPLEA	Real	-	1.	Half minimum wavelength alongtrack
SAMPLEC	Real	-	1.	Half minimum wavelength crosstrack
Area-mean option parameter				
AREASIZE	Real	-	Note 4	Side of area-mean bin (min)
Gravity model parameters				
MODEL	Char	-	BASELINE	Gravity model descriptor
SIGMAN12	Real	-	Note 5	Variance 1st Markov undulation model
SIGMAN22	Real	-	Note 5	Variance 2nd Markov undulation model
BETAN1	Real	-	Note 5	Reciprocal characteristic distance 1st Markov undulation model
BETAN2	Real	-	Note 5	Reciprocal characteristic distance 2nd Markov undulation model
SIGMAC2	Real	-	0.36	Variance Markov ocean current model
BETAC	Real	-	2.3809524E-5	Reciprocal characteristic distance ocean current model
USDFACT	Real	-	1.	Scale factor for NUMERIC model
Plot option parameters				
PLOT	Char	7	None	Plot descriptors
PLOTFILE	Char	-	None	Filename for output plot file
M1PLOT	Integer	-	50	Number east spacings for 3-D, CONTOUR
M2PLOT	Integer	-	50	Number north spacings for 3-D, CONTOUR
Survey options				
SURVEY	Char	5	None	List of survey descriptors
Parameters for ALT1 survey				
ORBINC	Real	-	115	Satellite orbit inclination (deg)
HEITALT	Real	-	8.E5	Satellite altitude (m)
TRKSP	Real	-	30	Separation of equator crossings (nm)

SAMPALT	Real	-	0.1	Time between samples (sec)
CA	Real	-	0.36	Altimeter white-noise level (m**2)
ALTVAR	Real	-	0.25	Variance of altimeter bias (m**2)
ALAM	Real	-	1.E-6	Inverse standard deviation bias model (1/m)

Parameters for ALT2 survey

ORBINCP	Real	-	108	Satellite orbit inclination (deg)
HEITALTP	Real	-	8.E5	Satellite altitude (m)
TRKSPP	Real	-	80	Separation of equator cross- ings (nm)
SAMPALTP	Real	-	0.1	Time between samples (sec)
CAP	Real	-	0.01	Altimeter white noise level (m**2)
ALTVARP	Real	-	0.25	Variance of altimeter bias (m**2)
ALAM	Real	-	1.E-6	Inverse standard deviation bias model (1/m)

Parameters for GRAVSHIP survey

SE	Real	-	0.25	East data spacing (nm)
SN	Real	-	6	North data spacing (nm)
CG	Real	-	1.E-12	White noise level (m/sec**2)**2
QQ	Real	-	0.75	RMS Eotvos error (mgal/measurement)
GRAVXTENT	Real	-	150	Maximum wavelength in model (nm)
EOTVOSW	Logical	-	.TRUE.	Eotvos error term switch
FULFUNC	Integer	-	0	Aliasing term switch

Parameters for GRAVLAND survey

SE	Real	-	81	East data spacing (nm)
SN	Real	-	81	North data spacing (nm)
CG	Real	-	9.E-10	White noise level (m/sec**2)**2
GRAVXTENT	Real	-	-10	Maximum wavelength (no limit if negative)
FULFUNC	Integer	-	1	Aliasing term switch

Parameters for SST survey

LOORBINC	Real	-	86	Low satellite orbit incli- nation (deg)
LOWEIGHT	Real	-	150	Low satellite altitude (km)

SSTTRKSP	Real	-	30	Separation of equator crossings (nm)
SSTSP	Real	-	10	Time between measurements (sec)
HIHEIGHT	Real	-	3.5786E7	High satellite altitude (m)
SSTLONG	Real	-	0	Region longitude relative to high satellite (deg)
SSTNOISE	Real	-	100	RMS white-noise level (micrometer/sec)
SSTFUNC	Integer	-	0	Switch to turn on full aliasing

Parameters for Gradiometer surveys

GRADSP	Real	-	10	Distance between tracks (km)
SAMPINT	Real	-	10	Time between samples (sec)
SPEED	Real	-	555.6	Speed of aircraft (km/hr)
HEIGHT	Real	-	6096	Altitude of aircraft (m)
GRADXTENT	Real	-	1500	Maximum wavelength (nm) (no limit if negative)
GRADFUNC	Integer	-	1	Switch for full aliasing calculation
SWGRAD	Logical	3	Note 6	Switches for gradiometer components
GRADROT	Logical	-	Note 7	Switch for umbrella geometry
RDNSE	Real	6	Note 8	Red noise values for GRAD survey
WHTNSE	Real	6	Note 8	White noise values for GRAD survey

Parameter for IMPACT phase

WAVELONG	Real	-	2700	Maximum wavelength to be included (nm)
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Parameters for Sensitivity option

SENSITIVITY	Char	-	None	Descriptor for dependent variable
VARIABLE	Char	-	None	Name of independent variable
VALUE	Real	20	None	List of values for independent variable

Notes:

- 1) For a run including the TRANSFER phase, TRANSFILE defaults to a temporary file. For a run including the IMPACT phase but not the TRANSFER phase, a filename must be supplied for TRANSFILE.

- 2) For a run including the GRAVITY phase, GRAVFILE defaults to a temporary file; if MODE=RMS or AREAMEAN, this default cannot be overridden. For a run including the IMPACT phase but not the GRAVITY phase, a filename must be supplied.
- 3) At least one USERFILE filename must be supplied for a MODEL=NUMERIC run; if MODE=RMS or AREAMEAN, up to three such files may be used, one for each of the regions of integration (see text).
- 4) If AREASIZE is not specified in the input, gravimetric covariances will be computed using AREASIZE values of 5, 15, 60, and 300 $\overline{\text{sec}}$. If AREASIZE is specified, only the single value entered will be used.
- 5) Default values for SIGMN12, SIGMN22, BETAN1, and BETAN2 depend on whether the BASELINE or the ACTIVE model is selected; they are listed in the text. These parameters are not used for other gravity models.
- 6) If not specified, all SWGRAD switches default to TRUE. However, if any of them is set to TRUE by the input, the others default to FALSE.
- 7) For Draper surveys, GRADROT is set to TRUE and cannot be overridden; for the other gradiometer surveys, it defaults to FALSE but may be overridden.
- 8) For all gradiometer types except GRAD, the parameters RDNSE and WHTNSE are set by the program and cannot be overridden. For the user-defined survey GRAD, values must be supplied for these parameters.

